HEATING SYSTEMS

Thermo E 200
Thermo E 320

with control unit 1586

Workshop Manual

Rev.02/2017
Id.No. 11114284B

Valeo

1 Introduction

1.1 Content and purpose

This workshop manual is used during maintenance and repair of water heaters (further referred to as heaters) Thermo E 200 und E 320.

ATTENTION:
Work on the heater may only be performed by briefed and/or trained by Spheros personnel.

1.2 Effectivity of the workshop manual

The workshop manual applies to heaters listed on the title page of this document.
It may be subjected to modifications and amendments. The respectively currently effectife version is binding. This version can be found on the Spheros homepage under Service/Downloads/Heating systems.

1.3 Meaning of highlighted content

Throughout this manual the emphasized words Warning!, Caution!, ATTENTION: and NOTE: used as follows:

Warning!	**Danger to life and health!**

This caption is used to indicate possible severe injuries or fatal accidents if instructions or procedures are carried out incorrectly or entirely disregarded.

Caution!	**Hazardous to health!**

This caption is used to indicate possible minor injuries if instructions or procedures are carried out incorrectly or entirely disregarded.

ATTENTION:

This caption points to actions which may cause material damage.

NOTE:
This caption is used to draw attention to an important feature.

1.4 Symbols

Symbol tightening torque value:
Identifies in graphics parts (eg nuts, bolts) that are to be mounted with a specific tightening torque. The torque values are shown at the symbol and are binding.

1.5 Further documentation to be used

The use of additional service literature is required. References are provided in the workshop manual at appropriate locations.
Use the following documents during operation and maintenance of the heaters:

- Operating and Service Instructions
- Installation Instructions
- Technical Information (TI)
- Spare Parts List

1.6 Safety information and regulations

Basically, general accident pevention provisions and the valid industrial safety directions must be adhered to. "General Safety Regulations" which exceed the framework of these provisions are listed below. The specific safety regulations which affect the present manual are issued highlighted in the individual sections or procedures.

1.6.1 General safety regulations

Warning!	**Danger to life and health!**

Read the Thermo E Operating and Service Instructions before operating the heater for first time.

Familiarize yourself with the Thermo E Installation Instructions before you make any modifications to the existing heater installation.

NOTE:

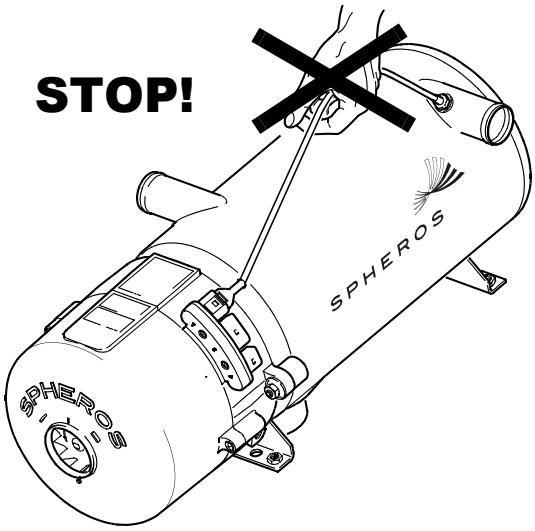
The Thermo E Operating and Service Instructions contain safety instructions and regulations to be followed for safe operation of the heater.

The Thermo E Installation Instructions contain the statutory regulations and other safety hints and regulations for the proper installation of the heater.

1.6.2 Other safety information

1.6.2.1 Temperature sensors

ATTENTION:
The temperature sensors cable may not be mechanically stressed (pull on the cable, carry the heater at the cable etc.).



1.7 Suggestions for Improvement and change

Please direct any complaints, improvement or modification suggestions regarding this manual to:

service@spheros.de

2 Technical data

Unless limiting values are defined, the technical data should be understood with tolerances of ±10% common for heaters at an ambient temperature of +20°C and at nominal voltage.

Table 201 Technical Data

Heater		Thermo E 200	Thermo E 320
Design		High-pressure atomizer	
Heat flow rate	kW	20	32
Fuel		Diesel / light fuel oil	
Fuel consumption	kg/h / l/h	2.0 / 2.7	3.2 / 4.1
Nominal voltage	V (DC)	24	
Operating voltage range	V (DC)	20.5...30.0	
Electrical power consumption at 24 V *	W	55	100
Combustion air intake temperature	°C	-40...+ 85	
Ambient temperature during operation	°C	-40...+ 85	
Storage temperature	°C	-40...+ 90	
Operating overpressure	bar	max. 2.0	
Heat exchanger filling volume	l	1.8	
Minimum water flow	± …l/h	2400 ± 200	2700 ± 200
Minimum coolant circulation volume	l	min. 25.0	
CO_2 in exhaust at nominal voltage	Vol %	9.5 ± 0.5	10.0 ± 0.5
Heater dimensions (tolerance ± 3 mm)	mm	Length 593 / Width 247 / Height 224	
Weight	kg	16.5	17.3

* without circulating pump
Max. continuous current of the circulating pump 8.75 A, max. peak current for 0.5 s duration = 90 A - We recommend the use of Spheros circulation pumps for highest efficiency and reliability! In order to reduce starting currents the circulating pump can be synchronized by the control unit for a short time period during activation. Confirm compatibility in case pumps provided by different manufacturers are used!

2.1 Electrical components

All heater components as well as the circulating pump and the timer are designed for 24V nominal voltage. The temperature sensor voltage is regulated by the control unit.

NOTE

Circulating pumps must be assigned to the heaters according to the flow resistance in the coolant circulation system.

2.2 Fuel

Suitable fuel is the diesel fuel specified by the vehicle manufacturer. Only the on the model plate of the heater specified fuel must be used.

The following table lists the by Spheros approved fuels and their specifications.

Fuel	Requirements acc.
Summer diesel	DIN EN 590
Winter diesel	DIN EN 590
Arctic diesel and Diesel for a strong winter climate	DIN EN 590
Bio diesel (FAME)*	DIN EN 12214
Paraffinic diesel fuel from synthesis or hydrogenation (HVO)*	DIN EN 15940

* Further information on approved fuels contains the TI (Technical Information) Fuels.
It can be found on the Spheros homepage under Service/Technical Updates/Heating systems.

In case of air temperatures below 0°C a commercial available winter Diesel fuel must be used.

The usage of flow improvers respectively additives is permitted. There are no negative influences due to additives known.

ATTENTION:

While using the fuels, their operating limits must be considered and if necessary, suitable measures (nozzle preheating, electrical heated filter) should be applied.

If fuel is supplied from the vehicle tank, follow the vehicle manufacturer's instructions on additives.

3 Description of assemblies and components

The water heaters Spheros Thermo E 200 and E 320, are used in conjunction with the vehicle heating system

– to heat the passenger compartment
– to defrost the windows as well as
– to preheat water-cooled vehicle engines.

The water heater operates independently from the vehicle engine and is connected to the cooling system, the fuel system and the electrical system of the vehicle. It is bolted to the vehicle chassis or is secured using an additional cross beam.
Heat is generated by combustion of liquid fuels. The heat it transferred to a coolant circulation system via the heater's heat exchanger. Intermittent operation adjusts the heater to changing heat demand.
The control unit controls heater activation and deactivation based on the temperature sensor signals.

The heaters of the Thermo E series mainly consist of the following main components:

– Burner
– Combustion chamber
– Heat exchanger

A circulating pump, preferably controlled by the control unit, is externally installed in the system, or for compact devices directly on the heater. An external control of the circulating pump (UPFA) is for the Thermo E not provided.
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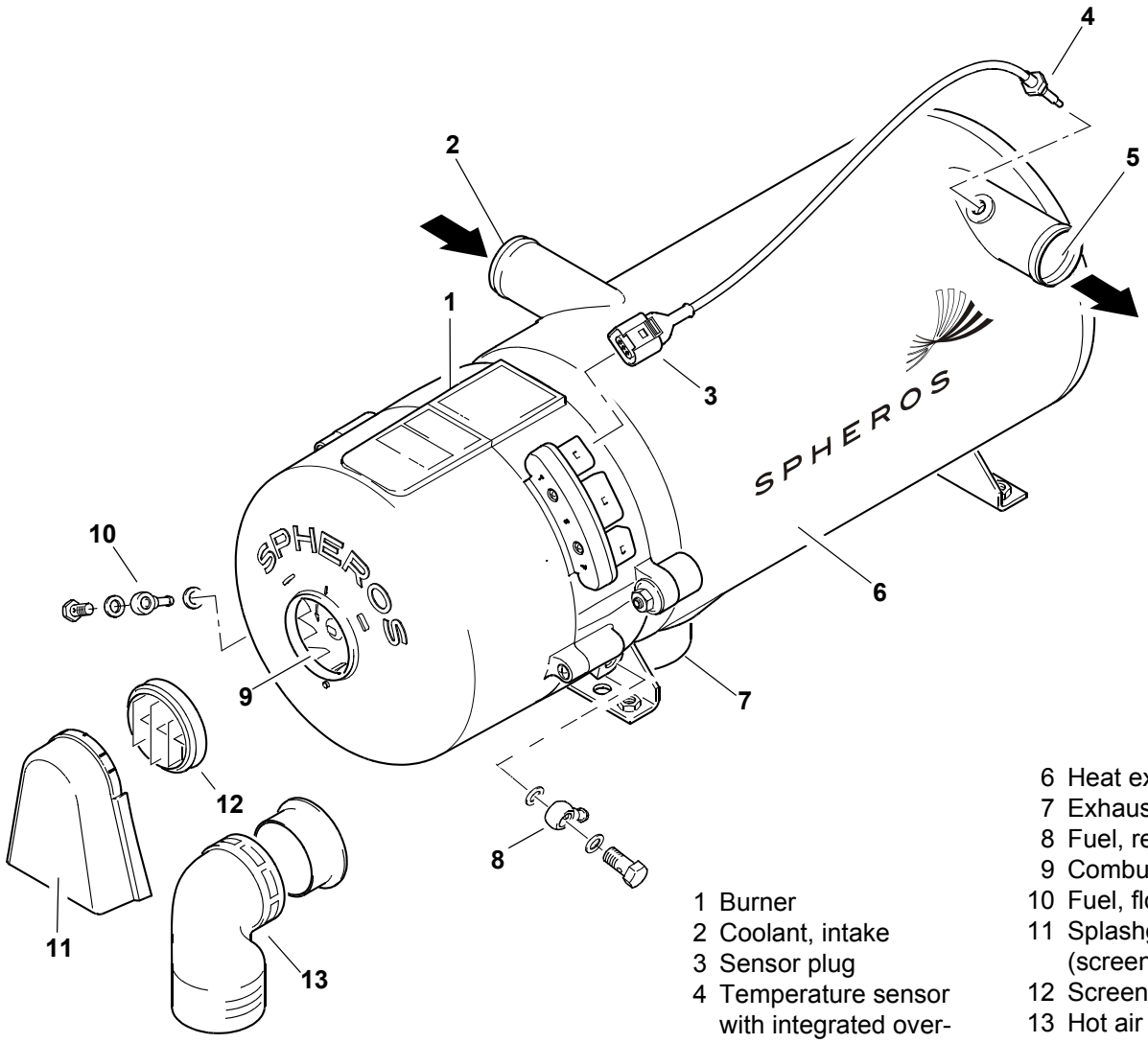


1 Burner
2 Coolant, intake
3 Sensor plug
4 Temperature sensor with integrated overheating protection
5 Coolant, outlet
6 Heat exchanger
7 Exhaust outlet
8 Fuel, return
9 Combustion air, intake
10 Fuel, flow
11 Splashguard (screen alternative)
12 Screen
13 Hot air elbow (incl. adapter) (screen alternative)

3.1 Burner

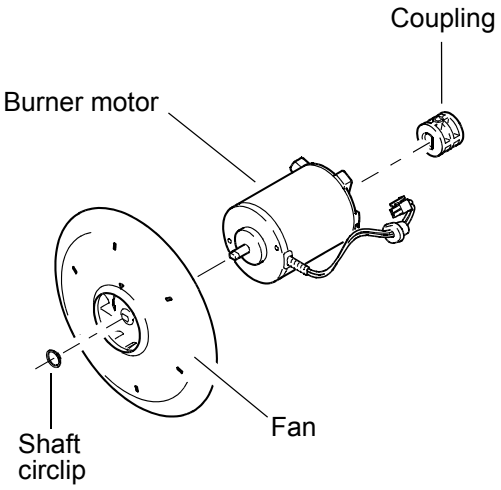
The burner consists of components

- Burner motor
- Combustion air fan
- Fuel pump with solenoid valve
- Atomizer nozzle
- Electronic ignition unit with ignition electrode
- Control unit with flame detector
- Disc with inspection glass
- Nozzle block preheater (optional)

3.1.1 Combustion air fan

The combustion air fan transports the air required for combustion from the combustion air intake to the combustion chamber.

The combustion air fan consists of burner motor and fan. Air is drawn in through the air intake opening in the hood. The air intake opening is equipped with a splashguard, a protective screen and a hot air elbow.

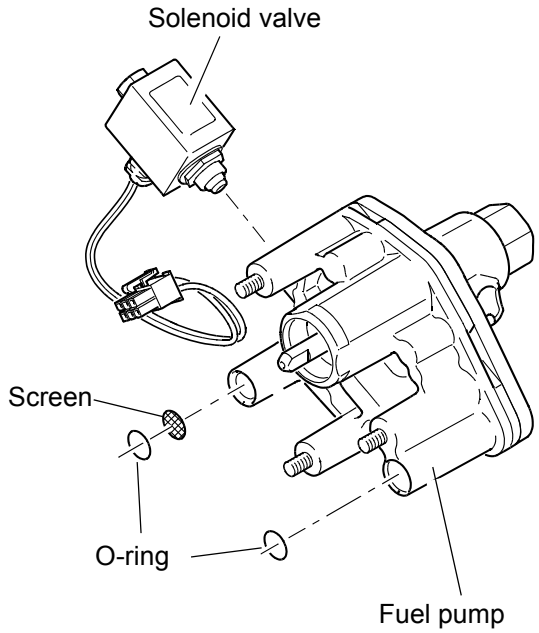


Two different motors are assigned to the different heating capacity classes of the Thermo E series. This assignment is clearly beyond the material number. The motors must not be interchanged.

NOTE:
The positioning of the motor to the housing is safely defined by a pin and a hole (see Fig. 803).

3.1.2 Fuel pump

The fuel pump is responsible for fuel supply.
The pump is driven by the burner motor via a coupling.
Fuel is compressed in the fuel pump to approx. 10 bar and atomized via the atomizer nozzle.
The solenoid valve integrated into the fuel pump opens and closes the fuel supply to the atomizer nozzle.
Identical fuel pumps are installed in heaters of both heating capacity classes.



The fuel pump is designed for dual-line operation (fuel supply and return line).

ATTENTION:
If the heater is operated with

- **a long fuel supply line (> 15m)**
- **check valves in the fuel supply and return line (> 0.07 bar)**
- **a fuel filter in the fuel supply line**

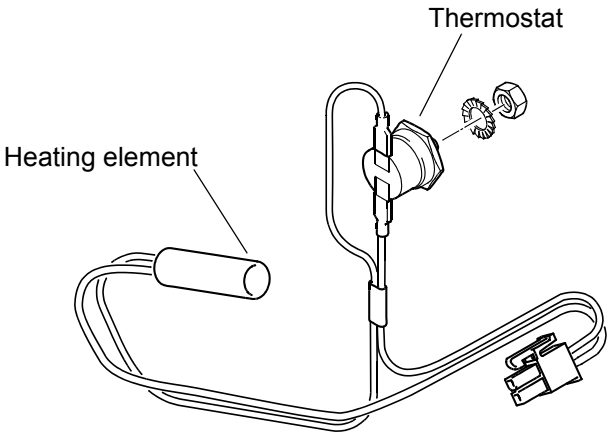
the fuel supply line and fuel filter are to be filled prior to first heater start-up (see 8.14.1).

3.1.3 Nozzle block preheater

In case of very low temperatures fuel may exhibit severely modified viscosity. Due to insufficient fuel atomization functional heater malfunctions may occur.

Depending on the fuel used, these temperatures vary. When used in cold regions or if fuels different from diesel fuel are used, we recommend the use of a nozzle block preheater.
The nozzle block preheater consists of a heating element with an integrated temperature sensor.
At a temperature of < 5°C the heating element heats the nozzle holder and thus, fuel and atomizer nozzle. Fuel viscosity is reduced and atomization improved.
The heating duration depends on the intake air temperature and on the reflected by the burner heat.
Above 8°C the thermostat turns the preheater off.

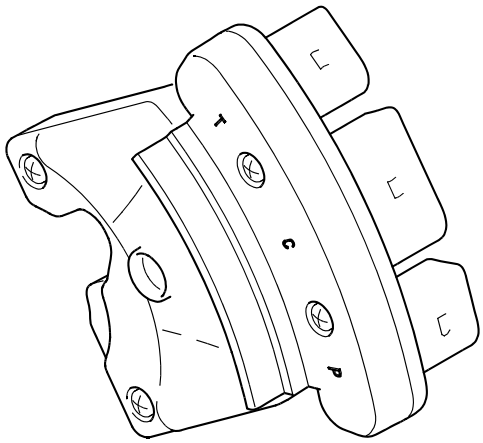
The use of the nozzle block preheater is optional. It is possible to retrofit this capability without modifications to the control unit.



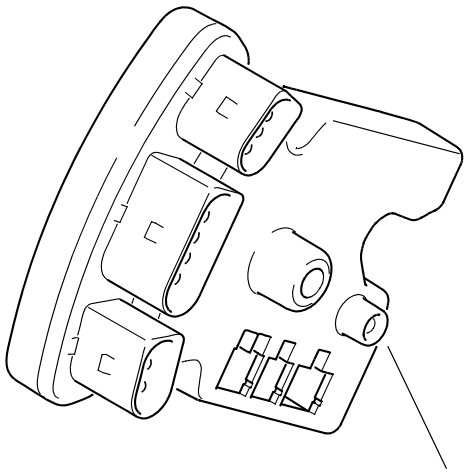
Nozzle block preheater

3.1.4 Control unit

The control unit 1587 ensures the operating sequence and burner operation monitoring.
The flame detector is integrated into the control unit.

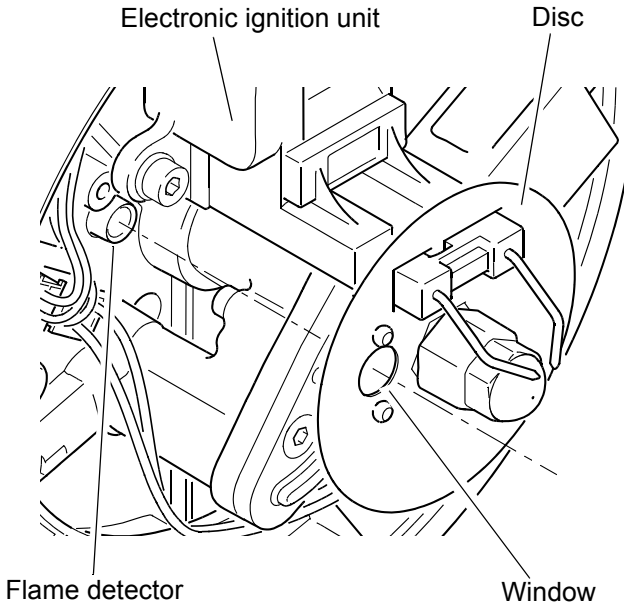


Control unit 1587



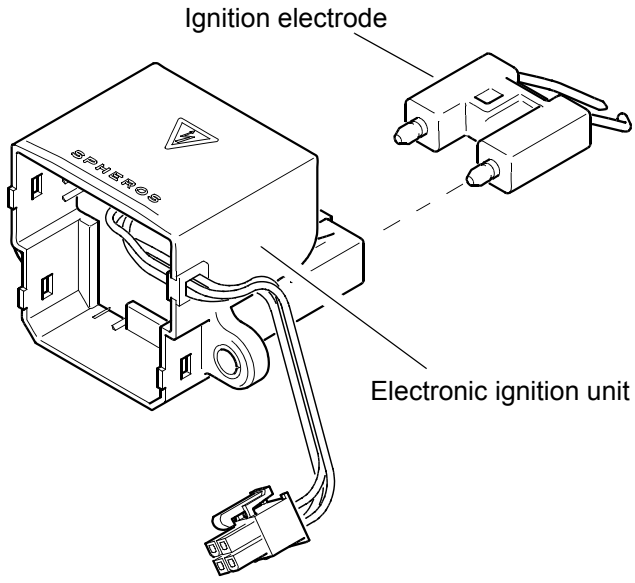
3.1.4.1 Flame detector

The flame detector monitors the flame conditions during heater operation.
The fame detector is a photo transistor, which changes its resistance as a function of flame luminous intensity and thus, the voltage applied.



3.1.5 Electronic ignition unit with ignition electrodes

The electronic ignition unit induces the high voltage required for ignition of the fuel-air mixture. Ignition is triggered by a high voltage spark, which is initiated on the ignition electrode.

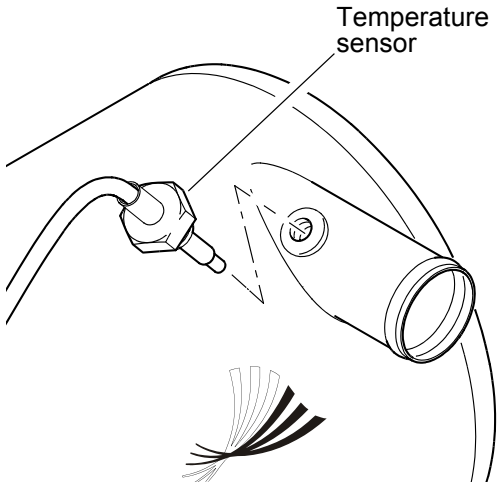


3.1.6 Temperature sensors with water temperature sensor and integrated overheating protection

The water temperature sensor captures the coolant temperature at the heat exchanger outlet as electrical resistance.

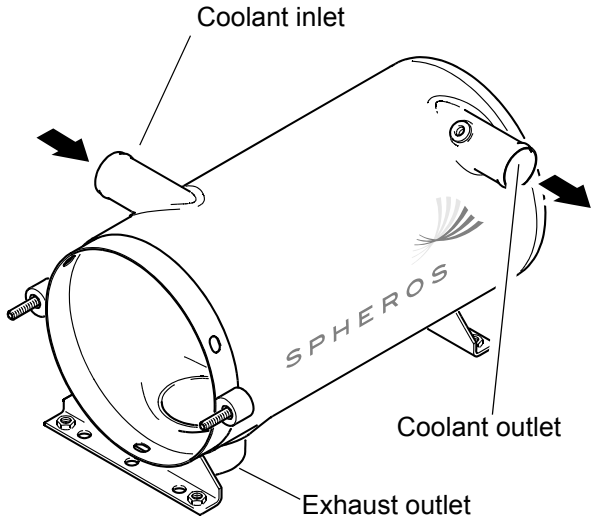
This signal is transmitted to the control unit, where it is processed.
The overheating protection integrated into the temperature sensor is responsible for temperature limitation. Similar to the water temperature sensor, the coolant temperature is captured at the heat exchanger outlet as electrical resistance and transmitted to the control unit. Overheating protection prevents inadmissibly high heater operating temperatures.
At a temperature greater than 125°C heater deactivation and interlocking is initiated.

It is not necessary to manually reset the overheating protection.



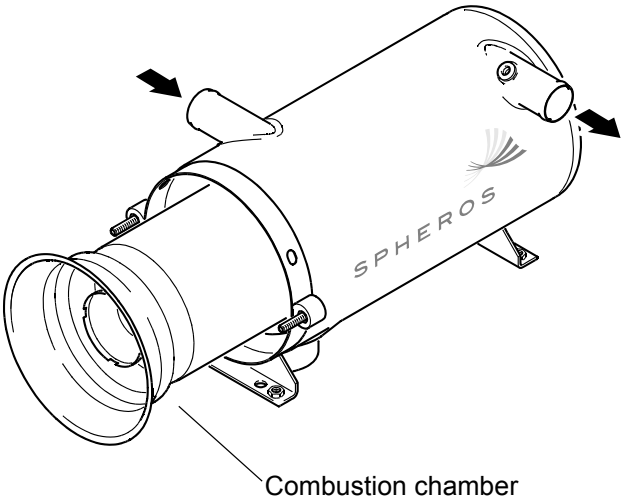
3.2 Heat exchanger

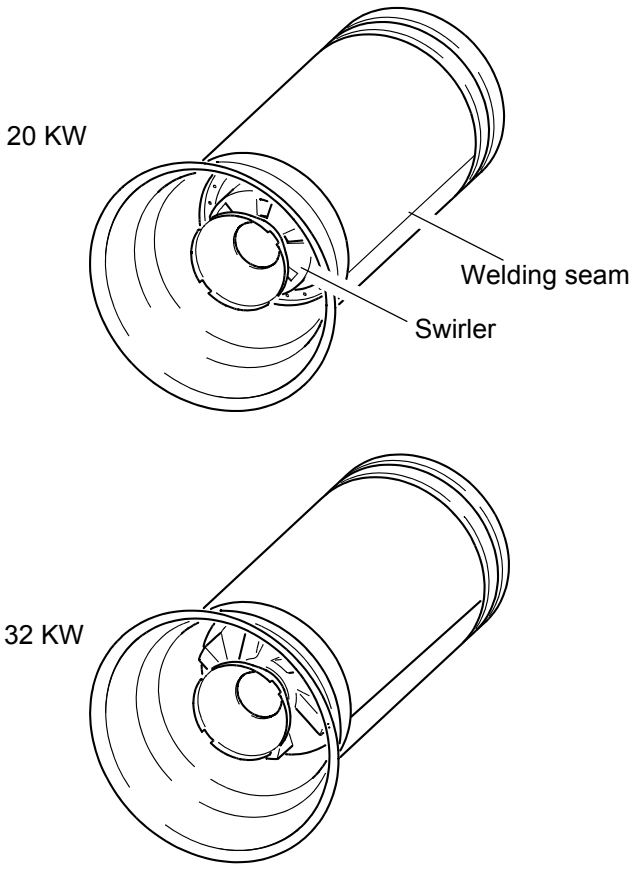
The heat exchanger transfers the heat generated by combustion to the coolant circulation system.



3.3 Combustion chamber

The combustion chamber is used for generation and combustion of the fuel air mixture. The generated exhaust gas heats the coolant flowing through the heat exchanger.





Depending on heating capacity class, different combustion chambers are used.
They have different swirler (E 200 sheet metal, E 320 cast iron). The combustion chamber of the Thermo E 320 is additionally equipped with a flame stabilization pipe.
The combustion chambers have an identification stamp according to the associated heater (E 200 or E 320).

ATTENTION:

Heater operation with a combustion chamber of a other heating capacity class is not permitted.

3.4 Circulating pump

The externally arranged circulating pump ensures coolant transport within the vehicle and/or heater circulation system.
Depending on the application, the circulating pump is switched on via the control unit or directly via the vehicle electrical system and operated during the entire heater operation duration.
Heaters can be operated with Aquavent 5000 (U4814), Aquavent 5000S (U4854), Aquavent 6000C (U4855) or Aquavent 6000SC (U4856) circulating pumps.

Circulating pump	Flow rate l/h	Nominal voltage V =	Operating voltage range V =	Nominal power consumption W	Weight kg
U 4814 Aquavent 5000	5000 (against 0.2 bar)	24	20…28	104	2.1
U 4854 Aquavent 5000S	5000 (against 0.2 bar)	24	20…28	104	2.2
U 4855 Aquavent 6000C	6000 (against 0.4 bar)	24	20…28	210	2.4
U 4856 Aquavent 6000SC	6000 (against 0.4 bar)	24	20…28	210	2.5

ATTENTION

The circuit breaker of the circulating pump may never be pulled, while the pump is running, and may not be replaced, when the pump is switched on.

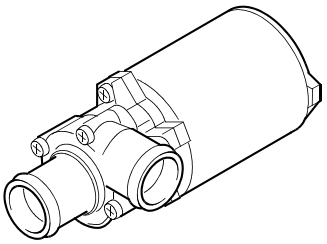
3.4.1 Aquavent 5000 (U4814) and Aquavent 5000S (U4854) circulating pumps

The Aquavent 5000 (U4814) and 5000S (U4854) circulating pumps are equipped with a brush motor.

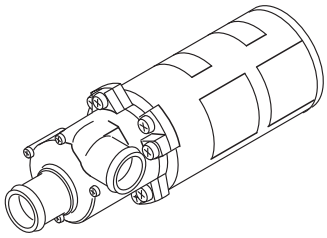
NOTE:
Aquavent 5000 (U4814) with floating-ring type shaft seal
Aquavent 5000S (U4854) with magnetic drive (no seal)

ATTENTION:

The circulating pump motor is not equipped with an internal inverse-polarity protection.



Aquavent 5000 (U4814)

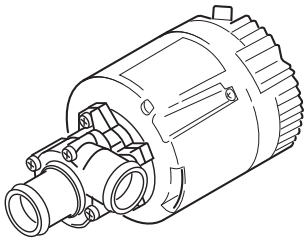


Aquavent 5000S (U4854)

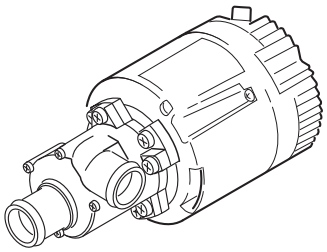
3.4.2 Aquavent 6000C (U4855) and Aquavent 6000SC (U4856) circulating pumps

The Aquavent 6000C (U4855) and Aquavent 6000SC (U4856) circulating pumps are equipped with a brushless motor.

NOTE:
The Aquavent 6000C (U4855) has a floating-ring type shaft seal.
The Aquavent 6000SC (U4856) is equipped wit a magnetic coupling (no seal)



Aquavent 6000C (U4855)



Aquavent 6000SC (U4856)

Soft start
The circulating pump motor starts slowly and gently. Max. rotational speed is only reached after approx. 5 seconds.

Protection against dry running
Protection against dry running is integrated into the circulating pump motor.
If the circulating pump motor consumes within a time period of approx. 45 minutes significantly less current, dry running is detected. The circulating pump motor is switched off.
After approx. 2 minutes and circulating pump motor reactivation, the operation can be continued.

Blocking protection
If the pump wheel is blocked, the motor will be switched off via the error mode directly prior to standstill of the pump wheel.

Overload protection
Overload protection is activated after the soft start is completed. The current consumption will be limited.
In case of hydraulic overpressuring of the circulating pump, the circulating pump motor will not be damaged.

Error mode
In case of malfunctions the circulating pump motor is switched off via the error mode. After approx. 5 seconds the error mode switches the circulating pump motor into energy-saving sleep mode.

Sleep mode
In sleep mode internal electronics consumers of the circulating pump motor are switched off.

Reactivation of the circulating pump motor
It is possible to reactivate the circulating pump motor from sleep mode. For this purpose the power supply is disconnected for > 2 min. After the power supply is reconnected, the circulating pump motor restarts in soft-start mode.

Inverse-polarity protection

ATTENTION:

The circulating pump motor is not equipped with an internal inverse-polarity protection.

3.5 Fuel filter

A heatable fuel filter is available as an option.
The integrated filter heating is switched on below of a fuel temperature of 0.5°C and off at a temperature of 5.5°C. When the heater is operated at temperatures below of -30°C the usage of this heatable fuel filter is absolutely necessary.

4 Heater functions

4.1 General heater functionality description

The heater principle is based on a high-pressure atomizer burner and is monitored by an integrated control unit.

The burner motor powers the fan and the fuel pump. The fuel pump is coupled to the motor using a coupling.
The fan produces the required combustion air, the combustion air volume is impacted by the burner motor speed.

The first CO_2 adjustment was made at Spheros.
For adaption to different applications (extension of combustion air intake or exhaust line) and after any maintenance and repair the CO_2 content is to be readjusted in a workshop.

The fuel pressure is generated in the fuel pump and reduced to the required pressure using a pressure limiting valve.
A solenoid valve releases the fuel via the atomizer nozzle for combustion in the combustion chamber.

As an option, the fuel pump can be equipped with a nozzle block preheater. The nozzle block preheater heats the nozzle holder with the atomizer nozzle at temperatures below 5°C and thus the fuel. The fuel air mixture is ignited in the combustion chamber via a high-voltage ignition spark.
The flame is monitored by a optical flame detector integrated into the control unit.

Depending on the equipment, the heater is switched on and off using a
- digital timer
- switch
- or climate control.

During heating operation the burner is automatically switched on and off. For regulation a temperature sensor is installed in the coolant outlet of the heat exchanger. The heater is switched on, when the temperature falls short of a lower temperature threshold (72°C), and is switched off, if the upper temperature threshold is reached (82°C).
A distinction between parking heating and auxiliary heating mode does not exists.

For overheating protection of the heater the switching thresholds are modified by the control unit, if specified temperature gradients are exceeded (gradient evaluation).

An operating display is available for monitoring the operating status. The operating display is also used to output error messages in flash code.

4.2 Operational heater sequence

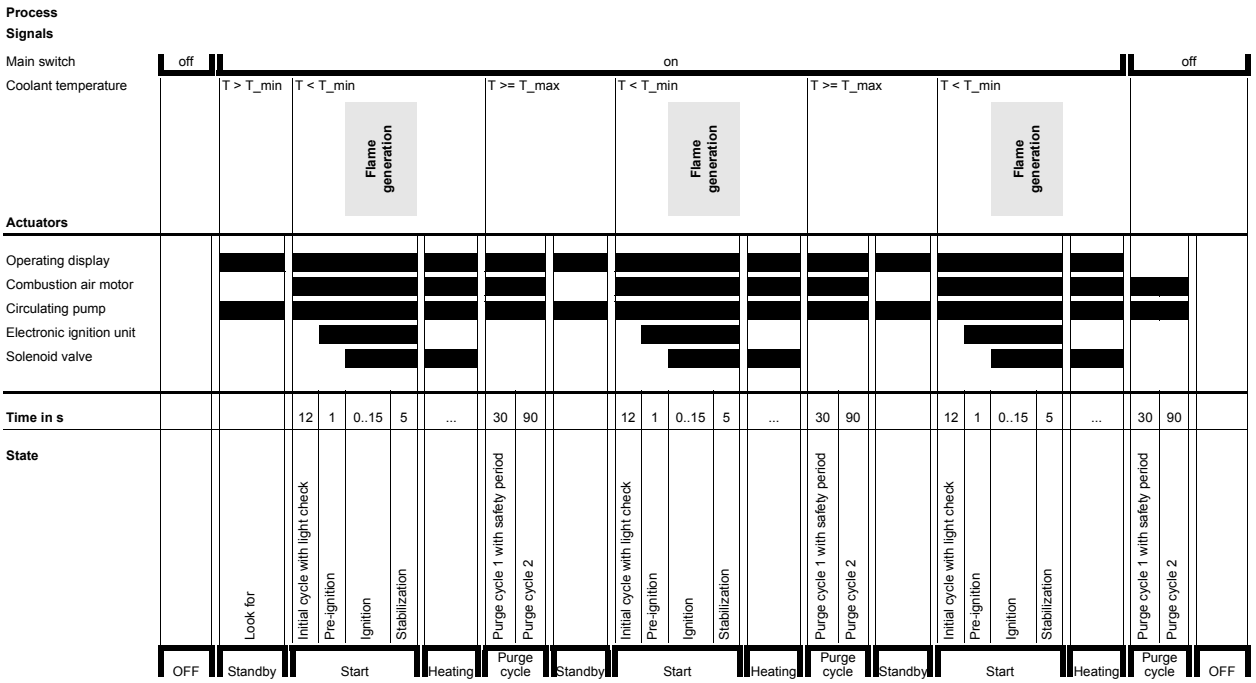


Fig. 401 Operational sequence

4.2.1 Switching on and start

When switched on, the operating display is illuminated, the control unit starts controlled operation and checks the coolant temperature.

If the coolant temperature is below the upper temperature threshold, the initial cycle starts.
Combustion air fan and circulating pump are switched on.

After approximately 12 seconds (initial cycle time) the high-voltage spark is ignited. Approx. 1 second later the solenoid valve in the fuel pump is opened.
The fuel injected via the atomizer nozzle and mixed with the air of the combustion air fan, is ignited by the ignition spark and burned in the combustion chamber.
The flame is monitored by a flame detector integrated into the control unit.
Approximately 5 seconds after a flame is detected, the control unit switches the electronic ignition unit off. Until then the flame is stabilized. The heater is not yet in heating mode.

With optional nozzle block preheater:
The heating element is in the control device in parallel connected with the motor output and is activated by the thermostat at temperatures below 5°C.

4.2.2 Heating operation

After the flame is stabilized, the heater is in controlled operation.

Once the upper switching threshold is exceeded, heating operation is finished and purge cycle initiated.
The solenoid valve is closed, the flame expires, however the combustion air fan and circulating pump continue running.
The purge cycle ends approx. after 120 seconds. The combustion air fan is switched off.
The heater is in a controlled break. The operating display is illuminated.

Once the temperature falls short of the lower switching threshold, the heater restarts burner operation. It runs through the same sequence as the switching-on sequence.

4.2.2.1 Gradient evaluation

In case of low coolant flow or poor coolant circuit venting the temperature may quickly increase during heating operation.
The control unit recognizes the quick temperature increase and automatically sets the upper switching threshold to a lower value.

The quicker the temperature increases, the lower the switching threshold for starting the controlled break is set.

In addition, the burner is also switched back on again after the controlled break at a lower switching threshold.

This prevents residual heat triggering the overheating protection.

If the temperature rise (temperature gradient) is again within permissible limits, the thresholds are reset to normal values immediately (lower threshold 72°C, upper threshold 82°C).

4.2.3 Switching off

Switching the heater off ends the combustion process. The operating display expires and purge cycle is initiated. The solenoid valve closes, the flame expires, the combustion air fan and circulating pump continue running. The purge cycle ends approx. after 120 seconds. The combustion air fan is switched off.

If a malfunction occurs during purge cycle (e.g. flame detection), the purge cycle may be shorter than 120 seconds.

During purge cycle it is permitted to switch the heater back on. The burner will restart after a purge cycle time of 30 seconds and subsequent initial cycle time.

4.3 Malfunction interlock and heater interlock

Malfunction interlocks and heater interlocks are distinguished.
The interlocks protect the heater and the surrounding vehicle assemblies against sequence errors after failure of individual heater components and particularly against impermissible thermal loads.

Thermal loads can be triggered by:

- Coolant flow too low
- Coolant circuit not or only partially filled (dry overheating)
- Circulating pump failure.

The control unit software detects overheating. Overheating is also detected by hardware (overheating protection), independently from software.

4.4 Malfunction interlock

If one of the malfunctions listed below occurs, the heater will initiate a fault shut-down, followed by malfunction interlock.
Depending on the error time, a purge cycle up to 120 seconds duration can be executed.
An error code is outputted by means of flash impulses via the operating display.
In case of several sequential malfunction interlocks a heater interlock is initiated (see 4.5).

4.4.1 Malfunctions during switching-on and start procedure

NOTE:
If malfunctions occur during switching-on or during the start process prior to ignition, the heater will be switched off without purge cycle.

The heater is in malfunction interlock.The motor stops immediately or does not start.

Malfunction criteria:
- Short circuit and/or interruption of electrical components:
  - Burner motor (stops immediately)
  - Electronic ignition unit
  - Optional nozzle block preheater
- Interruption of circulating pump operation
- Flame or extraneous light detection by the flame detector prior to ignition of the high-voltage ignition spark.
- No start: No flame detection within 15 seconds after opening the solenoid valve.
- Temperature sensor delivers unacceptable temperature values.
- Heater operation outside the permissible temperature range.
- Voltage falling short of the low voltage threshold of approx. 20.5 V at motor start or within a duration of 20 seconds after a heating request.
- Voltage exceeding the high voltage threshold of approx. 30 V at motor start or within a duration of 6 seconds (purge cycle only, no malfunction interlock).

4.4.2 Malfunctions during heater operation

NOTE:
In case of malfunctions during heater operation, first a 120 seconds purge cycle will be performed. Then the heater is switched into the malfunction interlock.

Malfunction criteria:
- Short circuit of the circulating pump.
- Short circuit or interruption of other electrical components (motor, solenoid valve, electronic ignition unit, nozzle block preheater).
- Water temperature greater than the upper switching threshold.
- Temperature sensor delivers unacceptable temperature values.
- Heater operation outside the permissible temperature range.
- Flame interruption (combustion interruption for longer than 15 seconds).
- Voltage falling short of the low voltage threshold of approx. 20.5 V at motor start or within a duration of 20 seconds after a heating request.
- Voltage exceeding the high voltage threshold of approx. 30 V at motor start or within a duration of 6 seconds (purge cycle is applied, but no malfunction interlock).
- Control unit malfunction.

4.4.3 Malfunctions during purge cycle

Malfunction causes:
- Short circuit or interruption of the burner motor (stops immediately)
- Interruption of circulating pump operation
- Heater operation outside the permissible temperature range.
- Voltage falling short of the low voltage threshold of approx. 20.5 V at motor start or within a duration of 20 seconds after a heating request.
- Voltage exceeding the high voltage threshold of approx. 30 V at motor start or within a duration of 6 seconds (purge cycle is applied, but no malfunction interlock).
- Control unit malfunction.

4.4.4 Malfunction interlock release and error clearance

The malfunction interlock is released when the heater is switched off.
After that it will be immediately ready for operation.

4.5 Heater interlock

The heater interlock overrides the standard malfunction interlock.

If the heater interlock is active, neither start nor purge cycle are executed after switching the heater back on.
Prior to restarting the heater troubleshooting must be performed by personnel trained by Spheros in order to identify the root cause.
After that the heater interlock can be released (see 4.5.1).

Here it is differentiated between interlocks caused by overheating and interlocks caused by other errors.

NOTE:
If malfunctions occur during switching-on or during the start process prior to ignition, the heater will be switched off without purge cycle.
The heater is in heater interlock state.
The burner motor stops immediately or does not start.
Besides that a purge cycle between 30 seconds and 120 seconds is performed depending on error type and timing.
Subsequently the heater status is switched to heater interlock.

Heater interlock causes:
- Short circuit and/or interruption of electrical components:
  - Solenoid valve
  - Flame detector
  - Overheating protection
  - Water temperature sensor
- Flame not expired within 30 seconds after purge cycle started (Burner motor stops)
- Overheating protection triggered
- Control unit error or programming error
- Repeated malfunctions (8)
- Repeated flame interruptions (5)

4.5.1 Heater interlock release

Temperature sensor, overheating protection errors or errors causing overheating cause a heater interlock in software and hardware.

ATTENTION:
The heater interlock release is permitted by Spheros trained personnel only.
The interlock must be released also in software and hardware.

For this purpose the heater must be disconnected from the vehicle electrical system twice.
The heater interlock release is performed using the following sequence:

1. Correct the cause of the heater interlock.
2. Switch interlocked heater on.
3. Disconnect the switched on heater for > 10 seconds from the vehicle electrical system.
4. Reconnect the switched on heater to the vehicle electrical system.
5. Within 120 seconds disconnect the switched on heater **again** from the vehicle electrical system.
6. Reconnect the switched on heater to the vehicle electrical system **again**.

NOTE:
The heater automatically starts after connecting it to the vehicle electrical system.
The heater can be switched off in the initial cycle.

4.5.1.1 Release of a heater interlock triggered by other malfunctions

1. Correct the cause of the heater interlock.
2. Switch interlocked heater on.
3. Disconnect the switched on heater for > 10 seconds from the vehicle electrical system.
4. Reconnect the switched on heater to the vehicle electrical system.
5. Within 120 seconds disconnect the switched on heater **again** from the vehicle electrical system.
6. Reconnect the switched on heater to the vehicle electrical system **again**.

NOTE:
The heater automatically starts after connecting it to the vehicle electrical system.
The heater can be switched off in the initial cycle.

4.6 Error output

If the heater is equipped with the standard timer, an error output is displayed on the digital timer after a malfunction occurs, otherwise via flash code at the operating display.

5 Troubleshooting and error correction

5.1 General

Warning!	Danger to life and health!

The safety information and regulations in Chapter 1 (see 1.6) must be adhered.

This section describes troubleshooting and error correction for Thermo E 200 and E 320 heaters.

In case of doubt functional connections can be obtained in chapters 3 and 4.

Error detection is usually limited to localizing the faulty component.
The following malfunction causes are not taken into account and should basically always be verified and/or a malfunction due to these reasons should be excluded:

- **Corrosion on plugs**
- **Loose plug connections**
- **Crimp failures on plugs and/or pins**
- **Corrosion on cable and fuses**
- **Corrosion on battery terminals**
- **Cable insulation damage**

ATTENTION:

Prior to replacing a fuse troubleshooting needs to be performed. The heater must be disconnected from the vehicle electrical system and the fuse is to be replaced when the heater is in currentless state.

A properly dimensioned fuse must be inserted (see chapter 6 Wiring diagrams).
After each error correction a functional test must be performed in the vehicle.

5.2 General error symptoms

The following table lists possible, general error symptoms.

Table 501: General error symptoms

Error symptom	Possible cause
Error in the electronics	
Operating display is not illuminated and the heater does not function.	• No supply voltage • Fuses • Supply cable to the plug contacts of plug A of the control unit
Fuse F1 triggered.	Short circuit or overload of cables, heater components or of the circulating pump Check cables, connectors and components and replace if required.
Fuse F2 triggered.	Short circuit in the supply cable to the main switch or, if installed, in the digital timer
Heater is functional, however the operating display is not illuminated	Operating display defective to cables to the operating display interrupted or shorted

Table 501: General error symptoms

Error symptom	Possible cause
Error in the water system Circulating pump not operating (Aquavent 6000S and Aquavent 6000SC only).	• Error mode activated. In case of malfunctions the motor is switched off via the error mode. **Reactivation of the circulating pump motor** For this purpose disconnect the power supply for > 2 min. After the power supply is reconnected the motor performs a soft start.
Heater stops as the connected heat exchanger provides insufficient heat.	<u>Flow rate too small, because</u> • Air in the heater, heat exchanger or in system sections. • Taps/valves (flow controllers) throttled, contaminated, closed. • Contaminations in the system, e.g. filters or at bottlenecks. • Circulating pump delivery rate insufficient (air in pump housing), • Insufficient frost protection. • System resistance too high (especially high in the cold). • Circulating pump defective. <u>Heat exchanger provides not enough heat, because</u> • Air in the heat exchangers and/or system sections. • Contaminated heat exchanger. • Insufficient air entry or air exit. • Fan: Insufficient delivery rate / incorrect direction of rotation / resistance too high. • Antifreeze content too high.

Approximate flow rate determination:

$$\text{Flow rate in [l/h]} = \frac{\text{Heat flow [kW] according to type plate}}{\text{Temperature difference } \Delta t \text{ in [K] or [°C] measured on the heater between water inlet and water outlet (e.g. using contact thermometer)}} \times 860$$

Table 501: General error symptoms

Error symptom	Possible cause
Error in the fuel supply No fuel delivery to the heater.	• Fuel tank empty. • Bent, closed, clogged or leaking lines. • Paraffin deposits or frozen water entrapments in fuel lines or lines. • Venting opening in tank closed. • Fuel lines mixed up. • Fuel filter contaminated. • Fuel screen (filter) in pump contaminated.
Error in the combustion CO_2 value cannot be adjusted to nominal value. Irregular combustion.	• Air bubbles in fuel supply line (leaking fuel supply line). • Fuel filter contaminated or leaking. • Fuel integration leaking (suction lift, low pressure in tank), observe installation instruction. • Fuel pump defective (pump pressure). • Screen (filter) in fuel pump contaminated. • O-ring seal on fuel pump ineffective (leaky or lack of O-ring). • Atomizer nozzle defective. • Combustion air and exhaust lines throttled or closed. • Burner motor speed too low. • Coupling defective.

5.3 Malfunction code output via flash code

The error cause is outputted as a flash code via the operating display.

After five short signals the long flash signals are counted.
The number of long flash impulses corresponds to the respective flash code. Flash codes and their respective error meaning are presented in Table 502.

Table 502 Blinkcode

No. of impulses	Error	Error description
0	Control unit error	Control unit error
1	No start within safety period	No start within safety period
2	Flame interruption	Flame interruption in burner operation, repeated starts unsuccessful
3	Low Voltage / high voltage	High voltage (> 30V, at least 6 seconds)
		Low Voltage (< 20.5V, at least 20 seconds)
4	Extraneous light in initial or purge cycle	Extraneous light (flame detector "Bright" in purge cycle 2)
		Extraneous light (flame detector "Bright" prior to ignition)
5	Flame detector defective	Flame detector short circuit
		Flame detector interruption
6	Temperature sensor / overheat protection defective	Temperature sensor short circuit
		Temperature sensor interruption
		Temperature sensor / overheat protection non-plausible
		Overheat protection short circuit
		Overheat protection interruption
7	Solenoid valve defective	Solenoid valve short circuit
		Solenoid valve interruption
8	Combustion air fan motor / nozzle block preheater defective	Combustion air fan motor short circuit
		nozzle block pre-heater short circuit
9	Circulating pump defective	Circulating pump short circuit
10	Overheat protection triggered	Overheating T>125°C
11	Electronic ignition unit defective	Electronic ignition unit short circuit
		Electronic ignition unit interruption
12	Heater interlock	Flame interruption counter threshold exceeded
		Heater interlock - release required
		Malfunction counter threshold exceeded

5.4 Error symptoms during functional tests with malfunction code output

5.4.1 Error symptom "No start within safety period"

If due to a malfunction the heater unsuccessfully attempted to start eight times in a row, it will be interlocked.
No further start attempts will be tried.
The heater interlock overrides the standard malfunction interlock.

The procedure for releasing the heater interlock can be found in point 4.5.1.

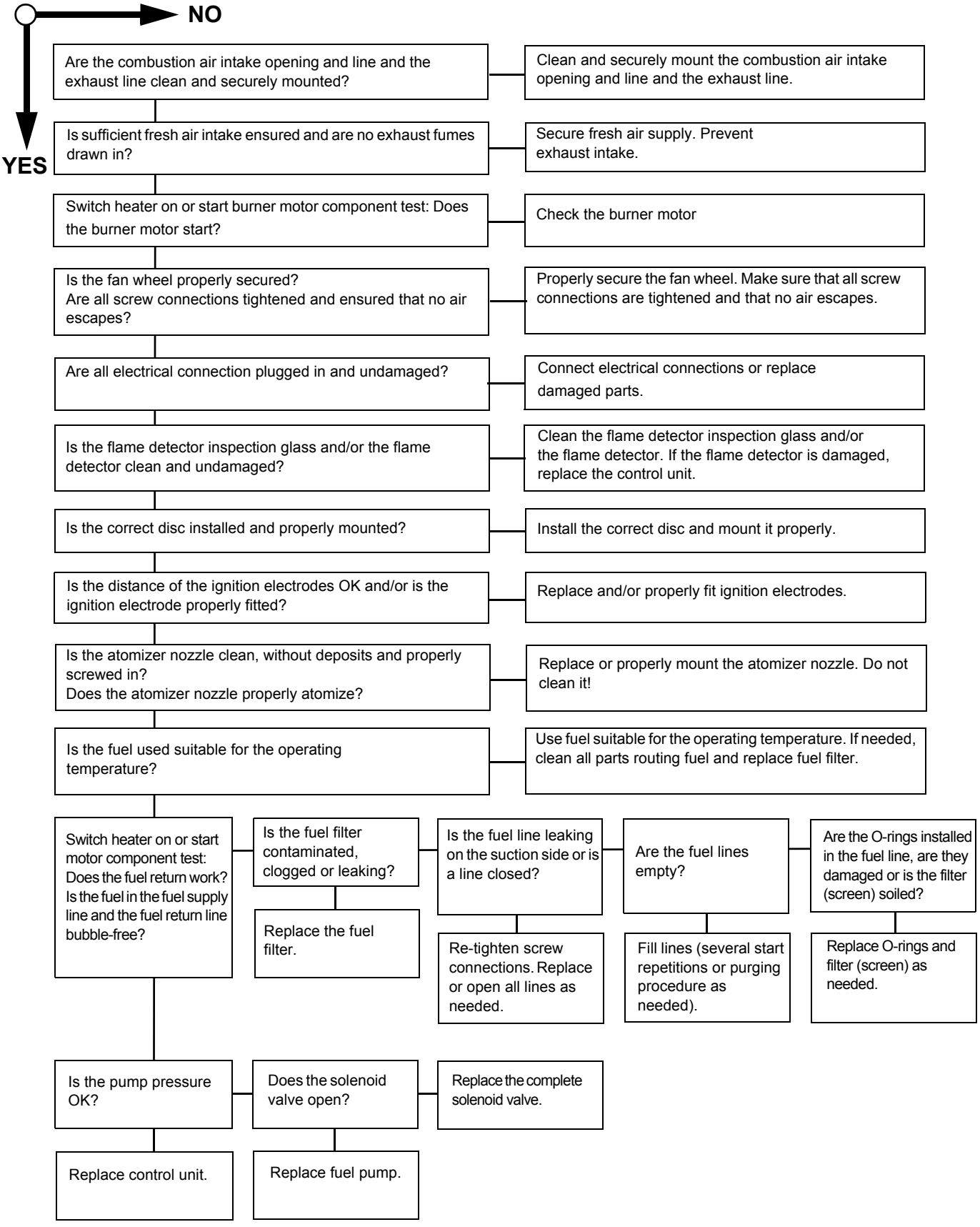
The "No start within safety period" error symptom does not always indicate that no ignition took place.
This symptom occurs as well, if the heater fails to enter heating operation (heating or auxiliary heating state) after successful ignition, e.g. in case the fuel supply is interrupted.

5.4.2 Error symptom "Flame interruption"

If due to a malfunction flame interruption occurs during heating operation five times in a row, the heater will be interlocked.
No further start attempts will be tried.
The heater interlock overrides the standard malfunction interlock.

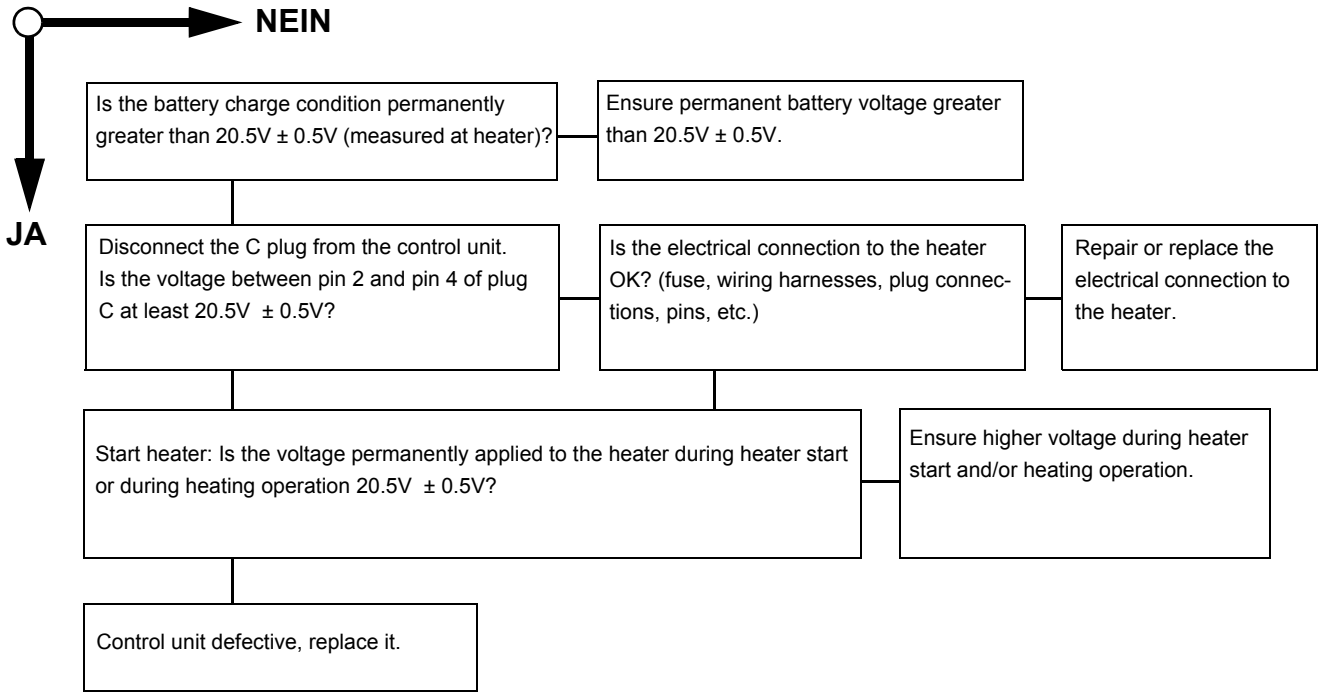
NOTE:
After above mentioned error symptoms occur, troubleshooting according to page 506 is recommended.

The procedure for a heater interlock release is outlined in point 4.5.1.

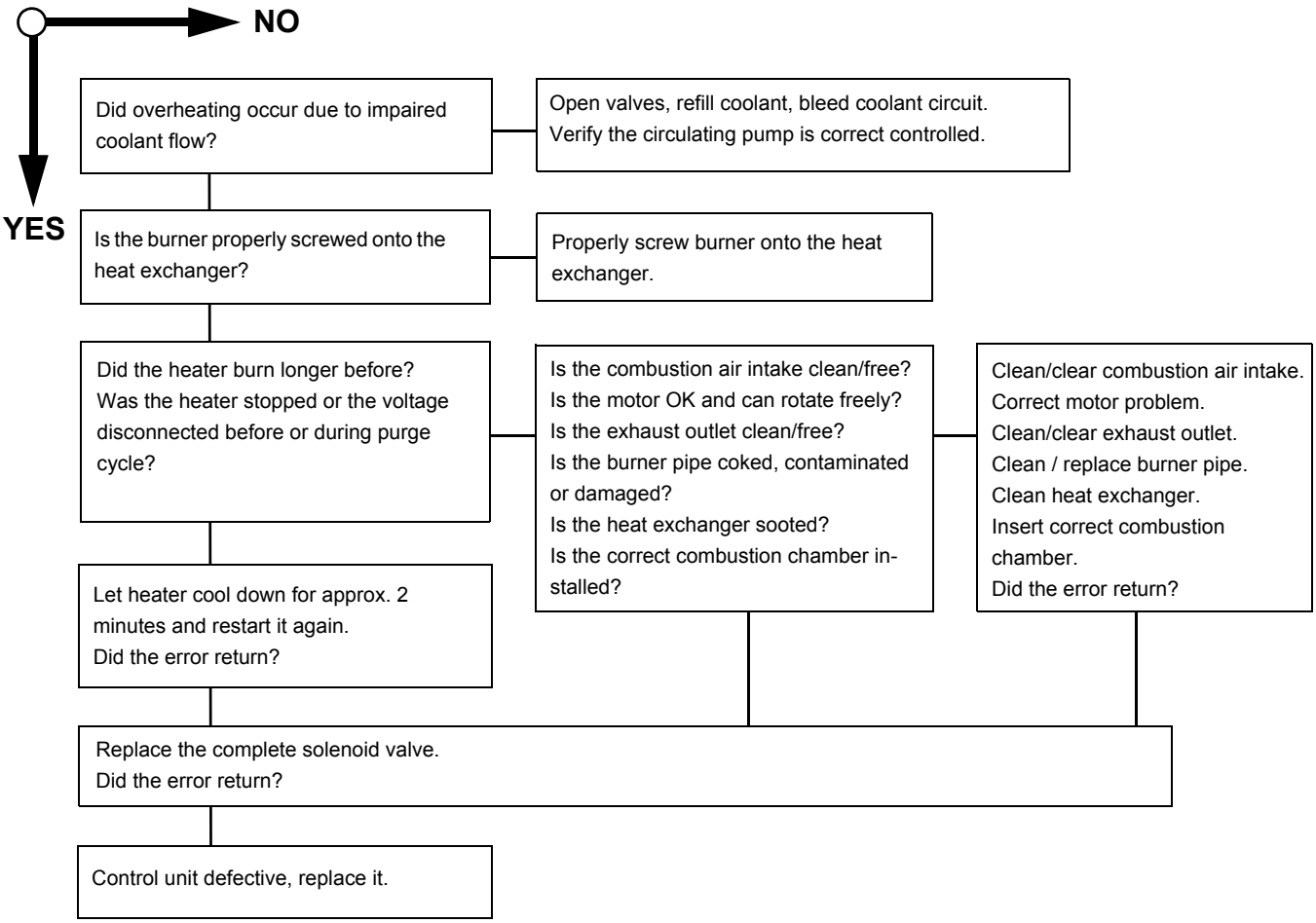

NO
YES
Are the combustion air intake opening and line and the exhaust line clean and securely mounted?
Clean and securely mount the combustion air intake opening and line and the exhaust line.
Is sufficient fresh air intake ensured and are no exhaust fumes drawn in?
Secure fresh air supply. Prevent exhaust intake.
Switch heater on or start burner motor component test: Does the burner motor start?
Check the burner motor
Is the fan wheel properly secured?
Are all screw connections tightened and ensured that no air escapes?
Properly secure the fan wheel. Make sure that all screw connections are tightened and that no air escapes.
Are all electrical connection plugged in and undamaged?
Connect electrical connections or replace damaged parts.
Is the flame detector inspection glass and/or the flame detector clean and undamaged?
Clean the flame detector inspection glass and/or the flame detector. If the flame detector is damaged, replace the control unit.
Is the correct disc installed and properly mounted?
Install the correct disc and mount it properly.
Is the distance of the ignition electrodes OK and/or is the ignition electrode properly fitted?
Replace and/or properly fit ignition electrodes.
Is the atomizer nozzle clean, without deposits and properly screwed in?
Does the atomizer nozzle properly atomize?
Replace or properly mount the atomizer nozzle. Do not clean it!
Is the fuel used suitable for the operating temperature?
Use fuel suitable for the operating temperature. If needed, clean all parts routing fuel and replace fuel filter.
Switch heater on or start motor component test: Does the fuel return work? Is the fuel in the fuel supply line and the fuel return line bubble-free?
Is the fuel filter contaminated, clogged or leaking?
Replace the fuel filter.
Is the fuel line leaking on the suction side or is a line closed?
Re-tighten screw connections. Replace or open all lines as needed.
Are the fuel lines empty?
Fill lines (several start repetitions or purging procedure as needed).
Are the O-rings installed in the fuel line, are they damaged or is the filter (screen) soiled?
Replace O-rings and filter (screen) as needed.
Is the pump pressure OK?
Does the solenoid valve open?
Replace the complete solenoid valve.
Replace control unit.
Replace fuel pump.

5.4.3 Error symptom "Low voltage"

A value is stored in the control unit as smallest "permissible low voltage".
It must be noted that the voltage may be lowered during heater start, and that the "low voltage" threshold may be violated.
Among others this depends on the vehicle electrical system, the temperature of optional components, such as the nozzle block preheater, circulating pumps or heatable filters.



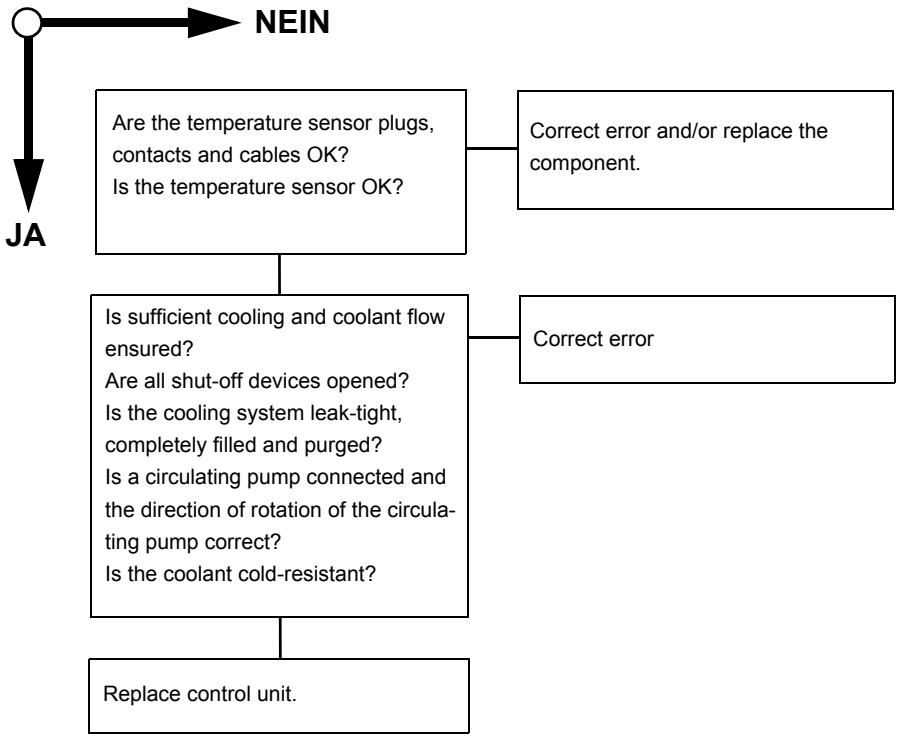
5.4.4 Error symptom "Extraneous light detected prior to ignition or during purge cycle"



5.4.5 Error symptom "Flame detector defective"

The flame detector cannot be replaced. Optionally the control unit is to be replaced.

5.4.6 Error symptoms "Temperature sensor / overheating protection defective" and "Overheating"



5.5 Individual component tests

Individual components can basically be tested using visual inspection or manual electrical testing.

NOTE:
Prior to disconnecting the temperature sensor plug connection, disconnect the heater from the vehicle electrical system.

5.5.1 General visual inspection

- Inspect components for damages (cracks, deformation, leaks, discolourations, etc.) and replace as needed.
- Inspect plugs and cables for corrosion, contact and crimp errors and repair as needed.
- Check plug contacts for corrosion and tight fit. Repair as needed.

5.5.2 Heat exchanger visual inspection

- Inspect heat exchanger interior for damage, corrosion, sooting and deposits.
- Inspect heat exchanger for outer damage, corrosion, moisture, deformations, deposits, discolourations, etc.

ATTENTION:

Soot and deposits in the heat exchanger must be removed, as they impact the heat transfer to the coolant.
Severe outer deformations may impact coolant flow.

5.5.2.1 Visual inspection of exhaust outlet and exhaust line

Inspect exhaust outlet and possibly available exhaust line for conditions, tight fit, contamination and deposits.
Use only exhaust gas deflections according to Installation instruction.

5.5.3 Combustion chamber visual inspection

- Remove combustion chamber (see 8.11).
- Inspect swirl plate and combustion chamber head for damage and tight fit.
- Check and remove combustion chamber for scalings and coke deposits as needed.
- Inspect combustion chamber for deformation and moisture.
- Inspect combustion chamber for cracks.

NOTE:
Cracks in longitudinal direction at the end of the welding seam shorter than 80 mm are permissible.

- After the inspection is completed, reinstall the combustion chamber (see 8.11).

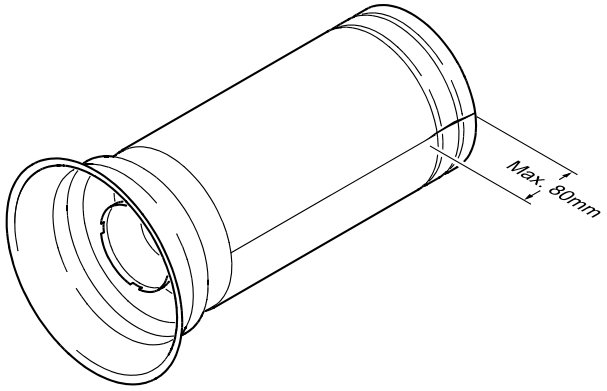


Fig. 501

5.5.4 Resistance check of the temperature sensor with integrated overheating protection

Caution!	Risk of scalds!

Observe the risk of injuries due to increased coolant temperature.
Prior to removing the temperature sensor, the overpressure in the cooling system must be released (e.g. by opening the cooler lid). Possibly let the heater before cool down and have collecting container ready for discharged coolant.

Inspection

- Inspect temperature sensor, plug and cable for damage and proper fit.
- Remove temperature sensor (see 8.3).
- Perform the electrical test using a measuring device suitable for resistance measurements.
- The electrical resistance between pin 1 and pin 3 (see Fig. 502) is at 0°C 500 Ohm, between pin 2 and pin 3 2000 Ohm. Both resistances change depending on temperature. The ratio should be at tempered through sensor 1:4.
- Install temperature sensor (see 8.3).

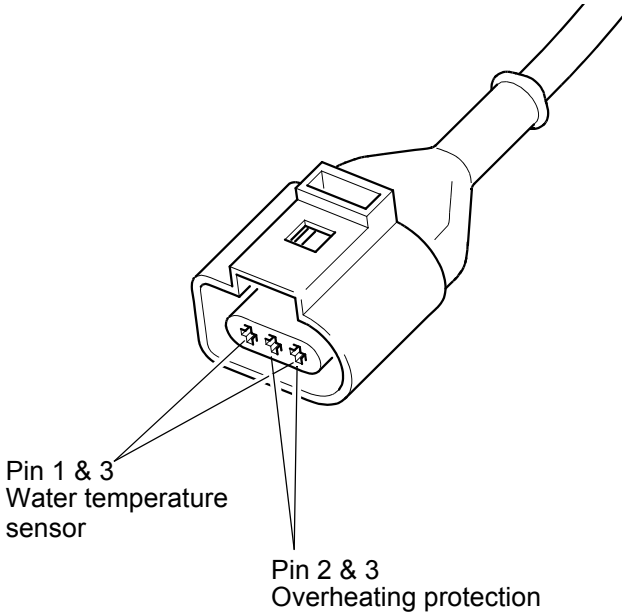


Fig. 502

5.5.5 Fan and combustion air intake line visual inspection

- Inspect a possibly available combustion air intake line for contamination, condition and deposits.
- Remove hood (see 8.4).
- Inspect fan channels for contamination and deposits.
- Inspect fan and motor shaft mount for cracks, stress marks and deformations.
- Check circlip for proper fit.
- Install hood (see 8.4).

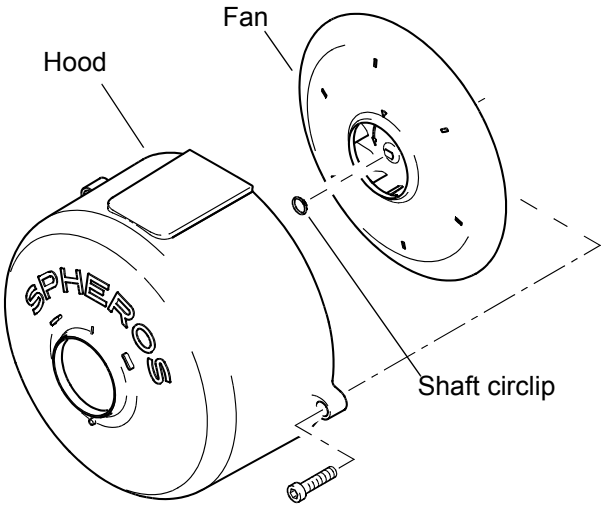


Fig. 503

5.5.6 Burner motor inspection

The motor can be checked by applying 24V DC voltage. The electrical connection to the control unit must be disconnected first.

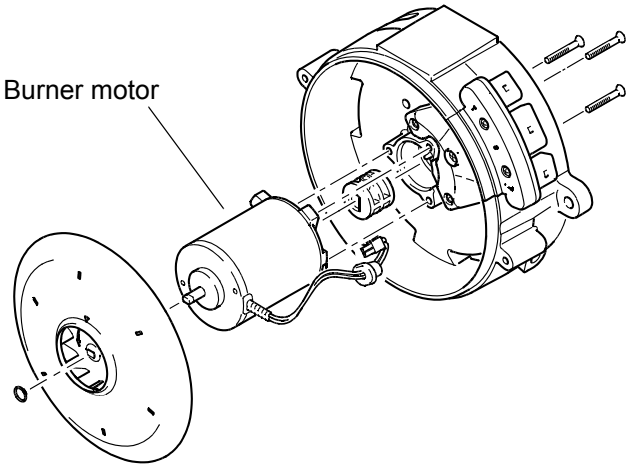


Fig. 504

- Disconnect the heater from the vehicle electrical system.
- Check wether the motor used corresponds to the heating capacity class.
- Inspect the motor for bearing conditions (stiffness). For this purpose remove hood as needed (see 8.4).
- Reconnect the heater to the vehicle electrical system.

5.5.7 Electronic ignition unit inspection

NOTE:

It can only be verified by visual inspection of the ignition electrode, whether the ignition spark jumps over to the ignition electrode.

Warning!	**High voltage! Danger to life!**

High voltage: The voltage received by the ignition electrode is >13,000 Volt.

During operation or testing of the electronic ignition unit, the ignition electrode may not be contacted by persons or items.

ATTENTION:

Do not test or apply voltage to the electronic ignition unit without an ignition electrode.

Inspect the electronic ignition unit for housing and end cover damage.
No mechanical damage may be caused or be present on housing and end cover.

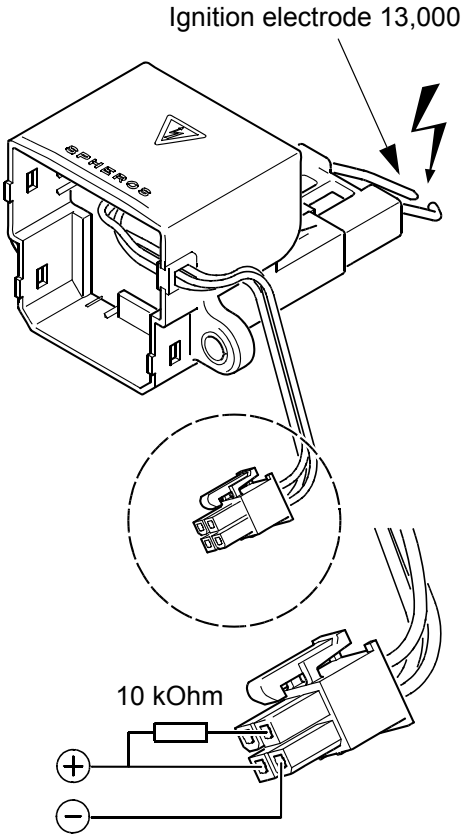


Fig. 505

Manual functional test when disassembled

- Remove electronic ignition unit (see 8.6).
- Connect ignition electrode.
- Apply 24V direct voltage according to Fig. 505.
- Nominal condition: Ignition sparks the ignition electrode jump over with a rate of 6Hz.
- After the test is completed, install the electronic ignition unit (see 8.6) and attach the ignition electrode.
- Install burner (see 8.2).

5.5.8 Ignition electrode inspection

NOTE:
The ignition electrode insulation may not be damaged. Ignition electrodes not functioning properly must be replaced.

ATTENTION:

Do not damage the electronic ignition unit when removing the ignition electrode.

Inspection

- Remove burner (see 8.2)
- Check distance of the electrode tip to the atomizer nozzle (see Fig. 506).
- Check the distance between the electrodes (see Fig. 506).

NOTE:
The distance between the electrodes may b measured using checking gauge, item number 310646.

- If needed, lift off ignition electrode (3, Fig. 805) from the electronic ignition unit by twisting a screwdriver sideways (see Fig. 804).
- Inspect the ignition electrode insulation for damage.
- Functionality is verified while inspecting the electronic ignition unit.

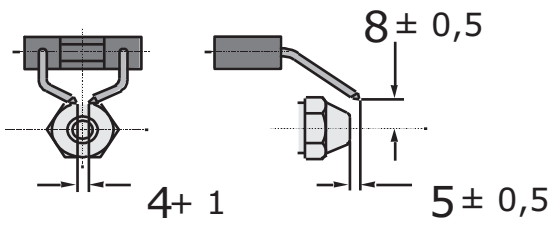


Fig. 506

5.5.9 Flame detector inspection

NOTE:
In case of contamination the glass body of the flame detector and the inspection glass in the disc (see Fig. 507) must be cleaned.
The flame detector is permanently integrated into the control unit and cannot be replaced.
The error diagnosis is possible only via the flash code (error code 5).

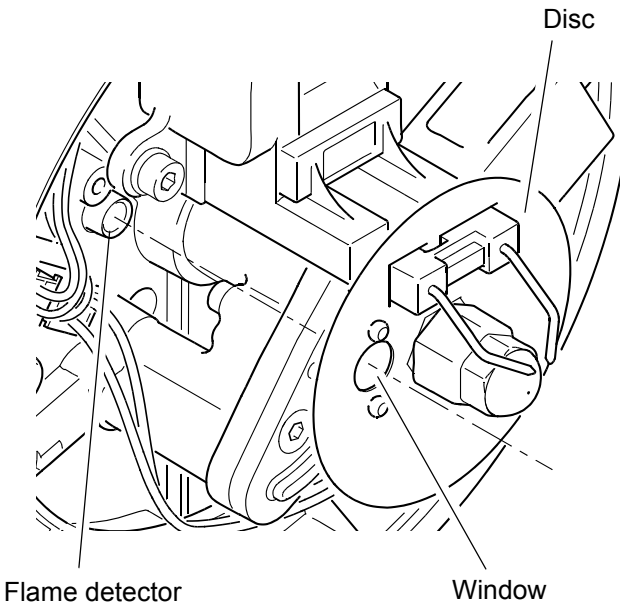


Fig. 507

5.5.10 Fuel pump inspection

ATTENTION:

The pump pressure of the fuel pump is adjusted to a fixed value in the factory.
The pump pressure can be re-adjusted.

The fuel pump and fuel hoses must be replaced after 5 years.

An admixture of up to 30% FAME to Diesel fuel is permitted.

NOTE:
If FAME is used, commonly designated as biodiesel, the fuel pump and fuel lines must be replaced according to the latest technical information / notification.

NOTE:
A pressure test gauge with a display range from 0 to 15 bar as well as a bleeding feature is required (Fig. 509). The pressure test gauge can be obtained from a Spheros Service Center or a distribution partner.

The following inspections should be performed prior to testing the pump pressure:

- Is the CO_2 content properly adjusted?
- Do the combustion chamber, atomizer nozzle and burner motor correspond to the heating capacity class?
- Does the motor reach nominal speed?
- Is the fuel temperature 15...25°C?
- Are available check valves in the fuel supply and return lines opened?
- Was the fuel filter in the fuel supply line replaced?
- Are the filters (screens) in the pump inlet clean?
- Is the fuel delivered without bubbles?
  Attach a transparent hose for testing.

The pump pressure can be checked as follows.

- In a workshop (not in the vehicle) fix the burner head.
- Disconnect motor and solenoid valve connectors from control device.
- Ensure fuel supply.
- Screw the pressure test gauge into the nozzle holder.
- Hook-up the motor and the solenoid valve with a 24V power supply (Observe the rotation direction of the motor! Pointer on the fan wheel).
- Open the bleed port at the pressure test gauge until some fuel escapes, collect it e.g. with a cloth. Close the bleed port and read the present pressure at the gauge.
- Compare the actual pressure with the target pressure in Tabelle 503.

If the specified pressure cannot be reached, it can be readjusted. For that rotate the adjusting screw (see Fig. 508) max. one revolution. If the prescribed pressure despite readjustment not be achieved or occur leaks, the fuel pump must be replaced.

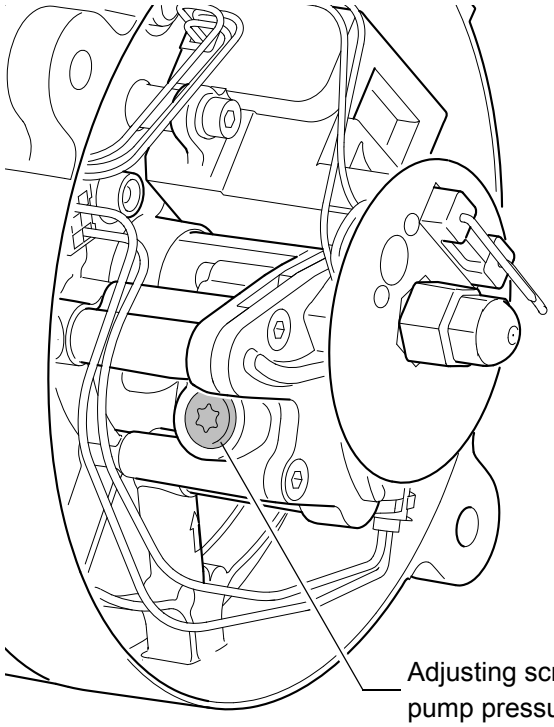
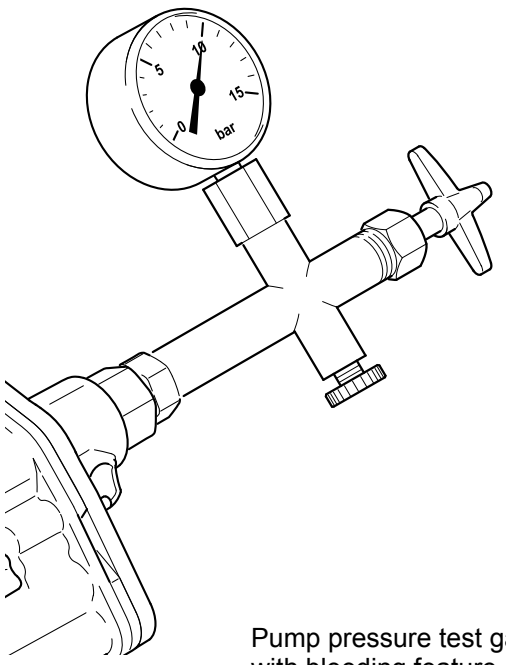


Fig. 508

- Dismantling in reverse order.

Tabelle 503 Fuel pump pressures

At 24.0V	Pump pressure
Thermo E 200	8 +1 bar
Thermo E 320	9 +1 bar



Pump pressure test gauge with bleeding feature

Fig. 509

5.5.11 Solenoid valve inspection

Caution!	**Risk of burns!**

The coil of the solenoid valve can heat up in switched-on condition.

The solenoid valve must only be completely replaced. In case of replacement or assembly a new gasket ring must be used.

NOTE:
Due to system characteristics draining the space between solenoid valve and nozzle bore may cause fuel dripping from the atomizer nozzle for a short period of time.
A leaking valve seat of the solenoid valve can be indicated by smoke development in the heater during the purge cycle. Fuel drips from the atomizer nozzle.
A not closing solenoid valve may cause heater deactivation during purge cycle with heater interlock activation.

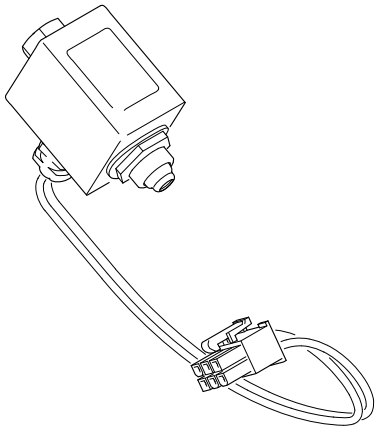


Fig. 510 Solenoid valve

The electrical function of the solenoid valve can be checked manually.

Manual inspection:

- Remove burner (see 8.2).
- Disconnect the solenoid valve plug from the control unit.
- Apply 24V direct voltage an check electrical function:
  - Opening voltage: ab 17.0 Volt
  - Power consumption at 24V and 20°C: 9 Watt
  - Nominal current at 24V: 0.37 Ampere

The solenoid valve must audibly open, when voltage is applied.

- Reconnect the solenoid valve plug to the control unit.
- Install burner (see 8.2).

5.5.12 Nozzle block preheater inspection

NOTE

At a temperature of < 5°C the heating element in the nozzle holder is switched on via a temperature sensor. The heating duration depends on the intake air temperature and on the reflected by the burner heat.
Above 8°C the thermostat turns the preheater off.
The power consumption of the heating element is at 24V approx. 80W.

Inspection

- Remove burner head.
- Disconnect the nozzle block preheater plug from the control unit.
- Connect an ohmmeter to the plug.
- Bridge over the thermostat
- Resistance max. 8 Ohm.

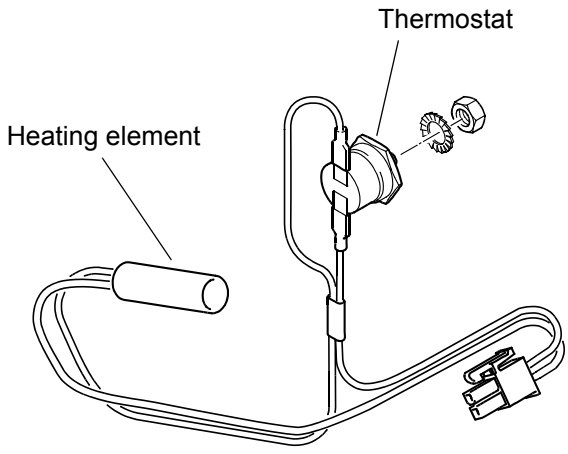


Fig. 511 Nozzle block preheater

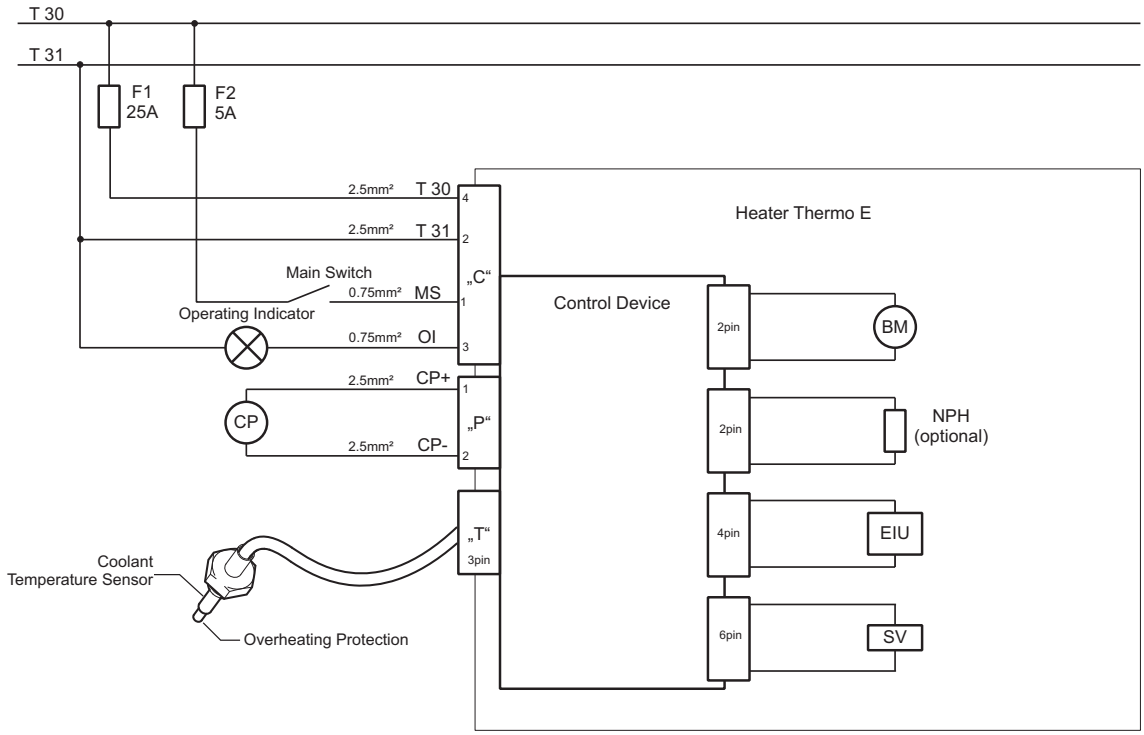
6 Wiring diagrams

6.1 General

The following figures represent heater connection options to the vehicle electrical system.

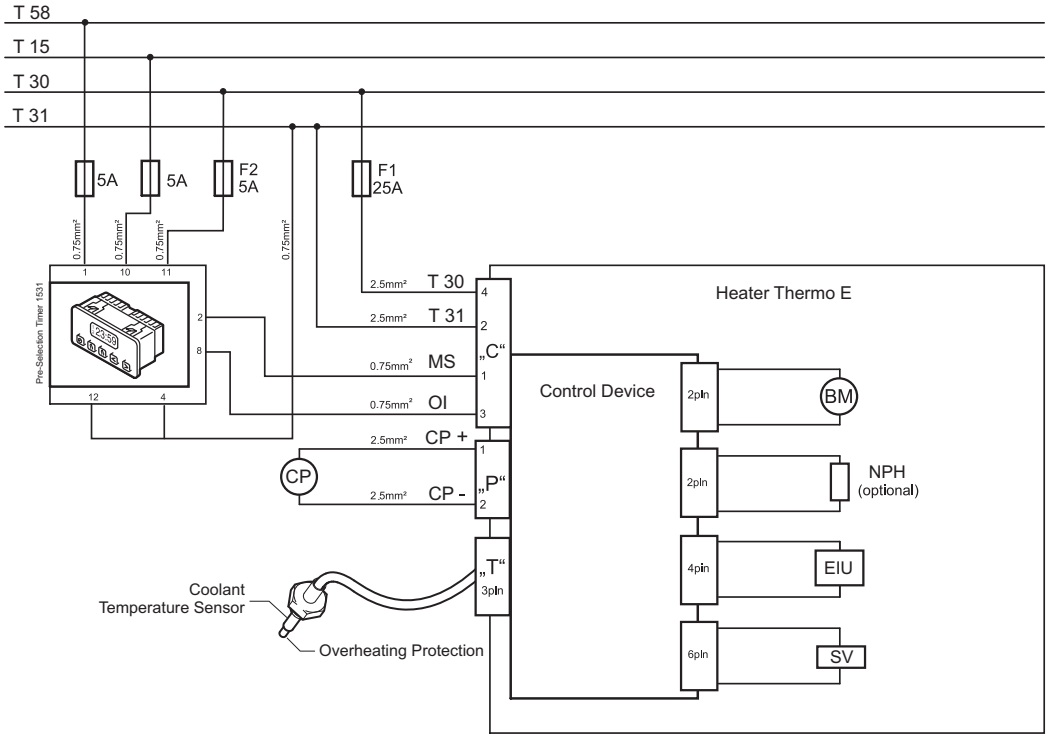
The in the table below shown cable cross-sections are to be used.

Cable length <7.5m	Cable length 7.5 - 15m
0.75 mm²	1.5 mm²
2.5 mm²	4.0 mm²



Cable cross-sections are effective for a maximum cable length of up to 7.5 m. For longer cables see table on page 601.

Fig. 601 System wiring diagram for heaters Thermo E, legend see page 603



Cable cross-sections are effective for a maximum cable length of up to 7.5 m. For longer cables see table on page 601.

Fig. 602 System wiring diagram for heaters Thermo E with pre-selection timer 1531, legend see page 603

Position	Designation
OI	Operation indicator max. 1x5W or 2x2W
BM	Burner motor
NPH	Nozzle block pre-heater
F1	Car flat-type fuse 25A acc. DIN 72581 part 3
F2	Car flat-type fuse 5A acc. DIN 72581 part 3
MS	Main switch
SV	Solenoid valve
CP	Circulating pump
EIU	Electronic ignition unit

Legend to the system wiring diagram

C	**To vehicle (Power)**	**T**	**Temperature sensors**
C1	Main switch	T1	Temperature sensor)
C2	Terminal 31 (–)	T2	Overheating protection
C3	Operation indicator +	T3	Ground
C4	Terminal 30 (+)	**V**	**Nozzle block pre-heating**
P	**Circulation pump**	V1	Nozzle block pre-heating +
P1	Circulation pump +	V2	Nozzle block pre-heating –
P2	Circulation pump –	Z	**electronic ignition unit**
B	**Burner motor**	Z1	electronic ignition unit +
B1	Burner motor +	Z2	electronic ignition unit +
B2	Burner motor –	Z4	electronic ignition unit –
M	**Solenoid valve**		
M3	Solenoid valve +		
M4	Solenoid valve –		

Connector pin assignment

7 Servicing

7.1 General

Warning!	Danger to life and health!

The safety information and regulations in Chapter 1 (see 1.6) must be adhered.

7.1.1 Heater servicing

For risk of overheating, the battery main current may not be disconnected, while the heater is operating or in purge cycle.
Make sure that the circulating pump is running while the heater is switched on for tests/inspections.

7.2 Servicing

In order to ensure long-term functional reliability, the following maintenance activities should be performed on the heater at least yearly, at the latest before the cold weather season starts.

NOTE:
If FAME is used (max. 30%!), the fuel pump and fuel lines must be replaced according to the latest technical information.

You can find an actual overview of all technical information on the Spheros homepage under Service / Technical Updates / Heating systems.

- In order to prevent malfunctions, the fuel filter and/or strainer as well as the fuel pump filter (screen) must be replaced at least once a year, in case of heavily contaminated fuel even more often.
- Yearly visual inspection of the fuel pump, fuel and coolant lines for leakage. In case of a leakage they must be replaced immediately otherwise after 5 years service time.
- Yearly atomizer nozzle replacement.
  The atomizer nozzle is a consumable thus not covered by warranty.
- Yearly visual inspection of inspection glass and flame detector glass body, clean as needed.
- Yearly visual inspection of the combustion chamber and heat exchanger interior for contamination and soot, clean as needed.
- Inspection of combustion air intake openings and exhaust port for contamination. Clean as needed.
- Outside the heating period, the heater should be operated every 4 weeks for 10 min. with the heater set to "warm" and cold vehicle engine.

7.2.1 CO_2 Measurement and setting

CO_2 Measurement

The exhaust should not be measured directly at the exhaust outlet of the heat exchanger, as this may cause inaccuracies.
Exhaust fumes should be sampled from the exhaust pipe in a distance of 350 mm after the heat exchanger. If no exhaust pipe is connected for this measurement a flexible hose of approx. 500 mm length (see accessories catalog) can be installed. At this place also the measurement of the exhaust gas temperature should be performed.
Increased exhaust temperature may indicate a sooted heat exchanger (see 5.5.2).

1. After a combustion period of approx. 3 min. measure the CO_2 content in the exhaust and compare it with the target value in Table 701.
2. Determine smoke number as needed: Target value according to Bacharach: ≤ 4.

The combustion air amount change is permitted an can be achieved by rotation of the adjustment ring.

The measurement of the CO_2 content in the exhaust gas and the adjustment of the combustion air amount is to be performed:

- after repairs at the burner
- in case of combustion irregularities
- in the course of a functional inspection
- after atomizer nozzle replacement
- for application adaption
- for permanent operation at large altitudes

CO_2 Setting

1. Measure the heater input voltage
2. Operate the heater approx. 3 min.

3. Measure the CO_2 content and the smoke number and compare readings with the appropriate diagram (see Fig. 701).

4. Loosen the fixation screw (see Fig. 702) and rotate the adjustment ring with the fixation screw until the target value is reached.

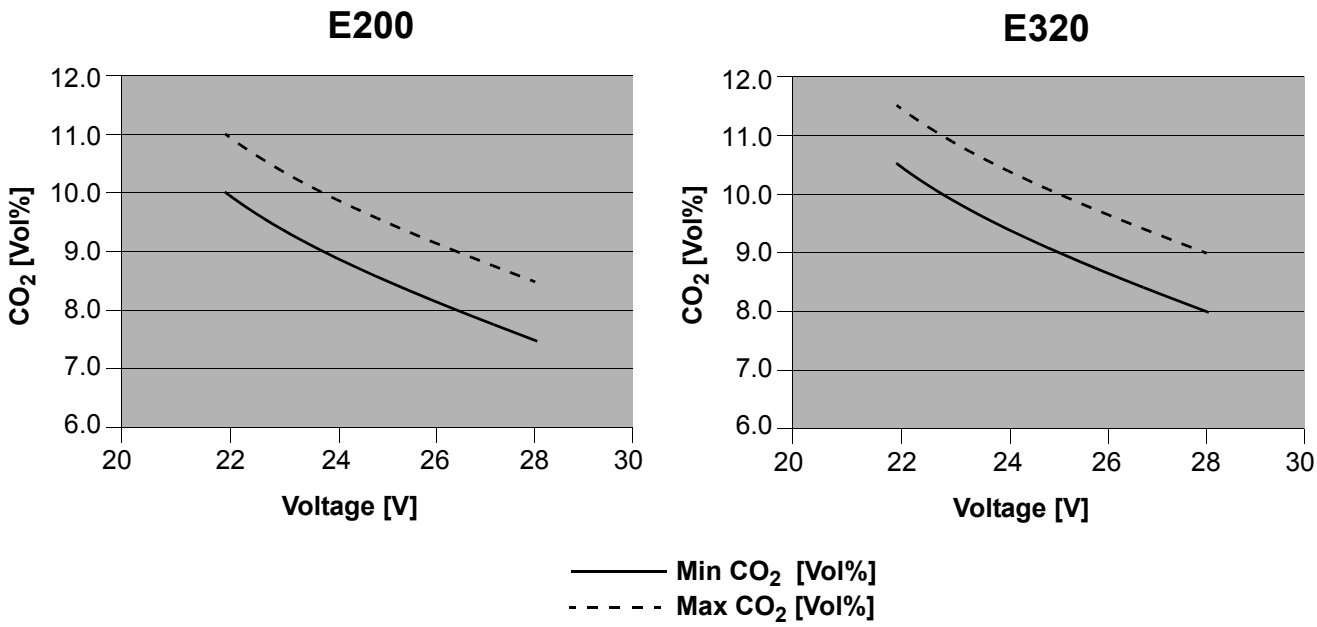


Fig. 701 Diagrams CO_2 value and dependency on voltage

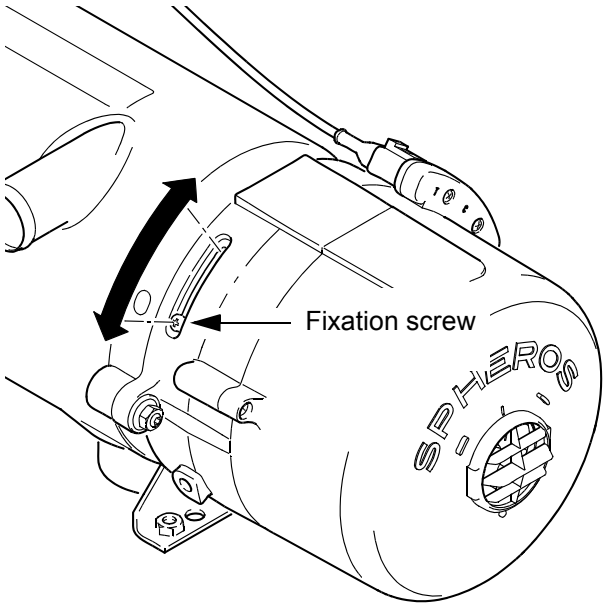


Fig. 702 Fixation screw for CO_2 setting

5. Torque fixation screw to 1.0 + 0.5 Nm and apply locking compound.

NOTE

The CO_2 setting depends on the fuel (viscosity) and the height above sea level (0.1% per 100 m).
If the CO_2 value cannot be adjusted to target value proceed as follows:

6. Check air intake side of burner head for damage and replace, if required.

7. Measure burner motor speed, replace burner motor as needed.

8. Check the fuel filter and the screen in the fuel pump for contamination and replace if required.

9. Check the fuel pump pressure and replace fuel pump if required.

10. Replace atomizer nozzle.

8 Burner, components and heater removal and installation

8.1 General

Warning!	Danger to life and health!

The safety information and regulations in Chapter 1 (see 1.6) must be adhered.

ATTENTION:

Prior to disassembling components the heater must be disconnected from the vehicle electrical system.

Sealing elements between disassembled components must be principally scrapped and replaced. This does not apply to the temperature sensor gasket ring, as it is permanently attached.
Screws with coated threads (screw locking) must be scrapped and replaced.

NOTE:
If components are disassembled to a degree not covered in this workshop manual, any warranty claim shall be voided.
Only genuine Spheros spare parts should be used.

Symbol tightening torque value:
Identifies in graphics parts (eg nuts, bolts) that are to be mounted with a specific tightening torque. The torque values are shown at the symbol and are binding.

Removing the burner provides access to the following components:

- Atomizer nozzle
- Fuel pump and solenoid valve
- Electronic ignition unit and ignition electrodes
- Disc with inspection glass for flame detector
- Nozzle block preheater (option)
- Flame detector (integrated into control unit)
- Combustion chamber
- Coupling

8.2 Burner removal and installation

Burner removal

1. Disconnect the heater from the vehicle electrical system and from the circulating pump as needed.
2. Disconnect the temperature sensor plug (5, Fig. 801).
3. If necessary, disconnect the combustion air intake line from the heater.

NOTE:

Make sure that any fuel leaking during the following work step is immediately bound and professionally disposed of.

4. Unscrew fuel lines and seal with blank plugs.
5. Unscrew nuts (2).
6. Remove burner (1).

NOTE:

Do not bent any lines when placing the burner down.

Burner installation

1. Bring burner (1, Fig. 801) in assembly position and ensure centre alignment and correct fit.
2. Place nuts (2) and alternately tighten them slightly.
3. Tighten nuts (2) and apply screw locking paint.
4. If applicable, bolt fuel lines down using a banjo bolt and new gaskets, or slide on fuel lines and secure with hose clamps.
5. If applicable, secure the combustion air intake line to the heater.
6. Connect the temperature sensor plug (5).
7. Connect heater with the vehicle electrical system and the circulating pump as needed.

1 Burner
2 Nuts (2)
3 Screws (2)
4 Hood
5 Temperature-sensor plug
6 Hollow screw

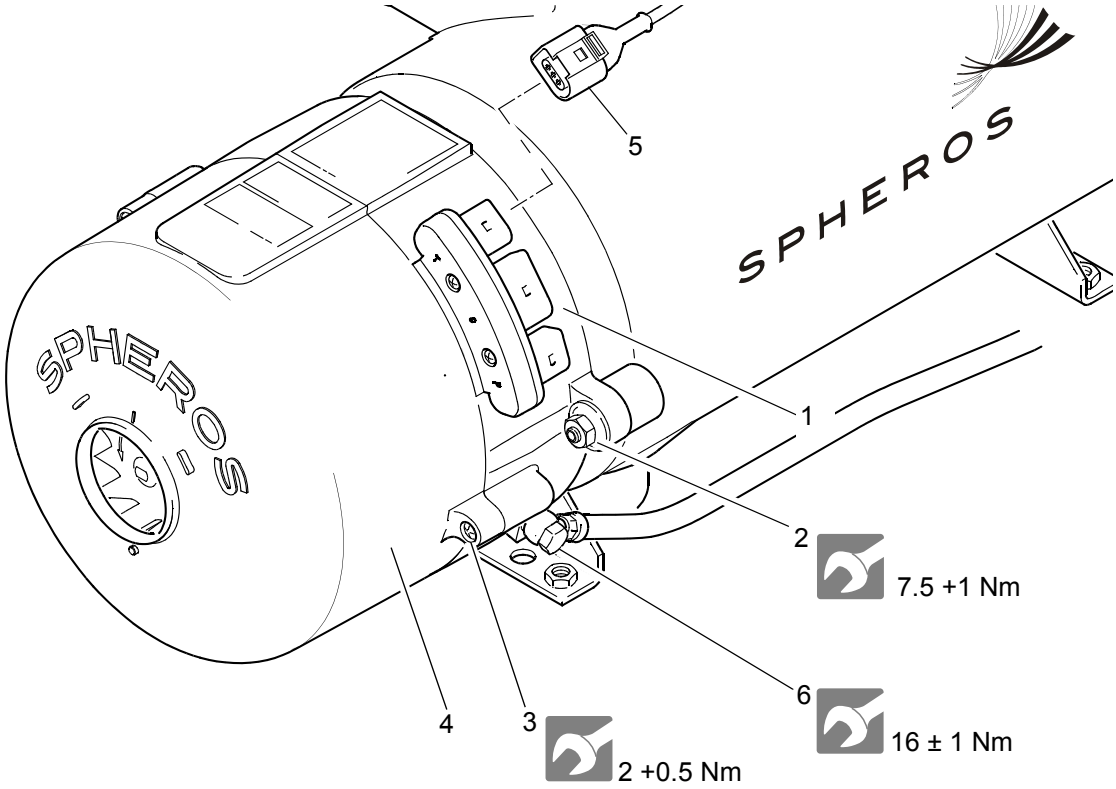


Fig. 801 Burner head / hood removal and installation

8.3 Removal and installation of the temperature sensor with integrated overheating protection

Caution!	Risk of scalds!

Observe the risk of injuries due to increased coolant temperature.
Prior to removing the temperature sensor, the over-pressure in the cooling system must be released (e.g. by opening the cooler lid). Possibly let the heater before cool down and have collecting container ready for discharged coolant.

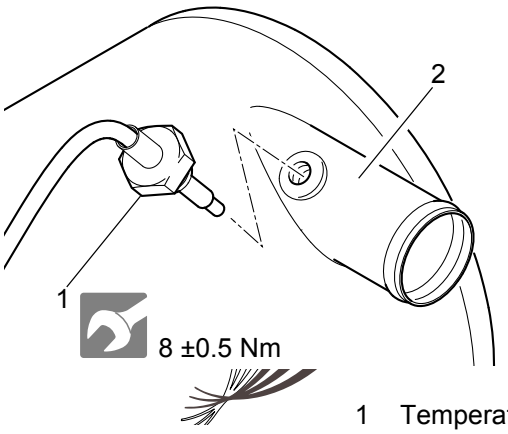
Removal
1. Disconnect the heater from the vehicle electrical system and from the circulating pump as needed.
2. Disconnect the temperature sensor plug (5, Fig. 801).

ATTENTION:

The temperature sensor is positioned directly in the coolant circuit. To prevent coolant from escaping as far as possible, the coolant hoses are to be closed with pinch-off pliers (331457).

3. Unscrew and remove temperature sensor (1, Fig. 802). Collect the escaping coolant.

Installation
1. Manually screw temperature sensor (1, Fig. 802) into coolant outlet (2).
2. Tighten temperature sensor (1).
3. Connect temperature sensor plug (5, Fig. 801).
4. Connect heater with the vehicle electrical system and the circulating pump as needed.



1 Temperature sensor
2 Coolant outlet

Fig. 802 Temperature sensor removal and installation

8.4 Hood removal and installation

Removing the hood provides access to the following components for maintenance, inspection and repair purposes:

- Fan
- Burner motor
- Control unit
- Coupling

Removal
1. Disconnect the heater from the vehicle electrical system.
2. If applicable, disconnect the temperature sensor (5, Fig. 801).
3. Loosen screws (3).
4. Remove hood (4).

Installation
1. Place hood (4, Fig. 801) in assembly position. Ensure centre alignment, proper fit and seal towards heater wiring harness.
2. Insert screws (3) and tighten.
3. If applicable, reconnect the temperature sensor plug (5).
4. Connect the heater to the vehicle electrical system.

8.5 Burner motor removal and installation

Removal
1. Disconnect the temperature sensor (1, Fig. 802).
2. Remove the burner (see 8.2).
3. Remove the fuel pump (see 8.8).
4. Disconnect the burner motor plug (6, Fig. 803) from control unit.
5. Remove the cable sleeve.
6. Remove the hood (1).
7. Remove the fan wheel (4). For that remove the shaft circlip using suitable pliers.

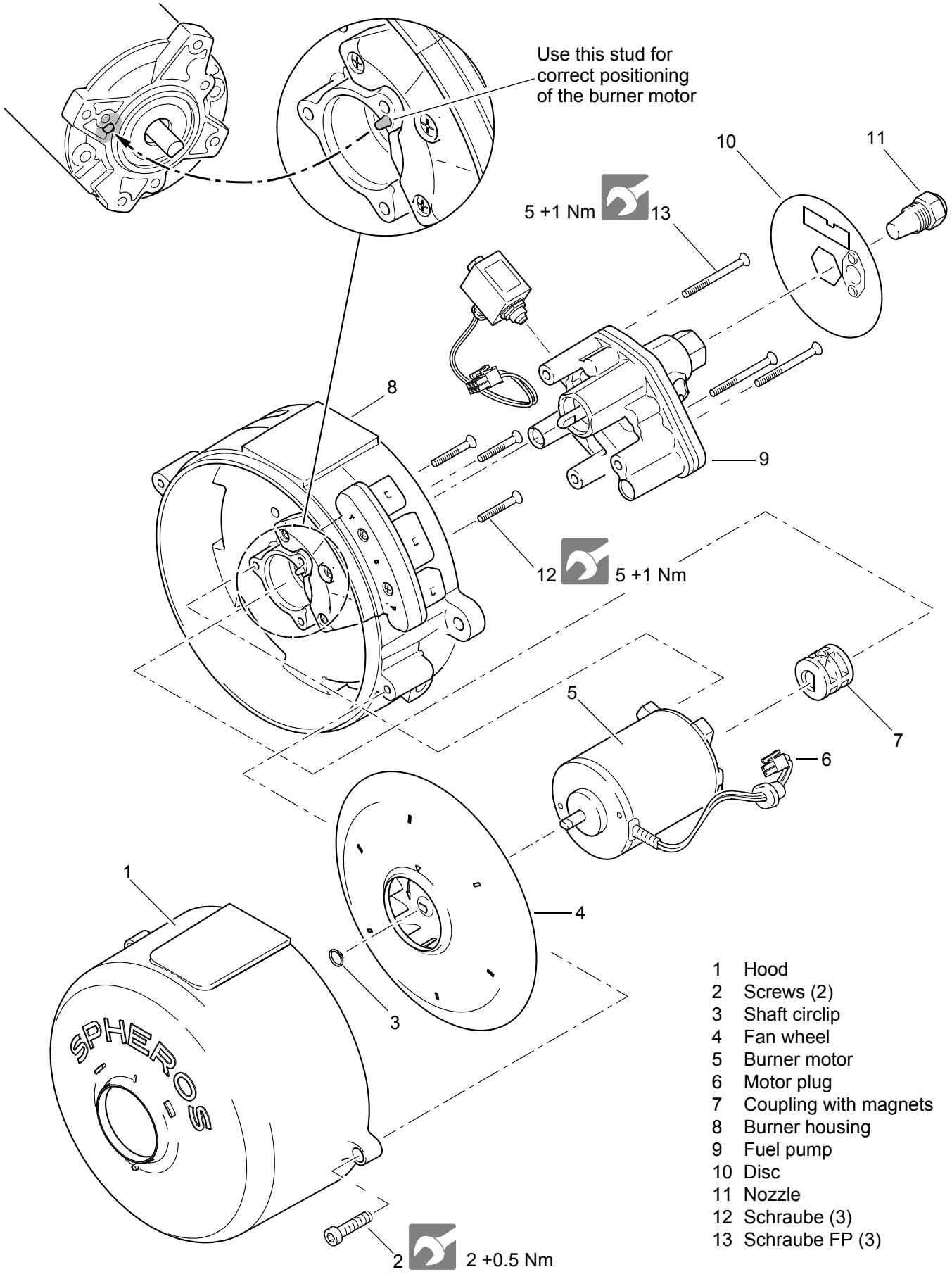
ATTENTION:

Do not overstretch the shaft circlip.

8. Remove the three countersunk screws.
9. Remove the burner motor (5).
10. Remove the coupling (7).

ATTENTION:

If the motor is replaced due to functional failure, also all plug connections at the control unit are to be checked and replaced as necessary.



1 Hood
2 Screws (2)
3 Shaft circlip
4 Fan wheel
5 Burner motor
6 Motor plug
7 Coupling with magnets
8 Burner housing
9 Fuel pump
10 Disc
11 Nozzle
12 Schraube (3)
13 Schraube FP (3)

Fig. 803 Burner motor removal and installation

Installation

1. Position motor (5, Fig. 803) onto the housing (stud at the housing and hole in the motor flange).
2. Secure motor (5) with three countersunk screws M5x35 .
3. Install fan (4). Install shaft circlip with suitable pliers.

ATTENTION:

Do not use an overstretched shaft circlip! Ensure secure engagement of the circlip in the groove!

4. Put the cable through the housing hole and install the sleeve.
5. Install hood (1) (see 8.4).
6. Connect plug (6) of the burner motor with the control unit.

NOTE:

The nozzle block pre-heater plug and the motor plug may be interchanged.

7. Slide the coupling (7) onto the motor shaft and pre-position it.
8. Install fuel pump (see 8.8).
9. Install burner (see 8.2).
10. Reconnect temperature sensor (1, Fig. 802).

8.6 Electronic ignition unit and ignition electrode removal and installation

Removal

1. Remove burner (see 8.2).
2. Lift off ignition electrode (2, Fig. 804) from the electronic ignition unit by twisting a screwdriver sideways.
3. Remove disc (3).
4. Removes screws (4) with retaining washers.
5. Pull electronic ignition unit (1) off and remove it.
6. If necessary, perform a general visual inspection (see 5.5.1) or test (see 5.5.7).

Installation

1. Bring electronic ignition unit (1, Fig. 804) into installation position, attach ready for connection and secure with screws (4).
2. Fit disc (5) onto the nozzle holder of the fuel pump (10, Fig. 805) and align with the flame detector in the control unit (15) and the electronic ignition unit.
3. Fit the ignition electrode (2, Fig. 804).
4. Install burner (see 8.2).

1 Electronic ignition unit
2 Ignition electrode
3 Disc
4 Screws (2)

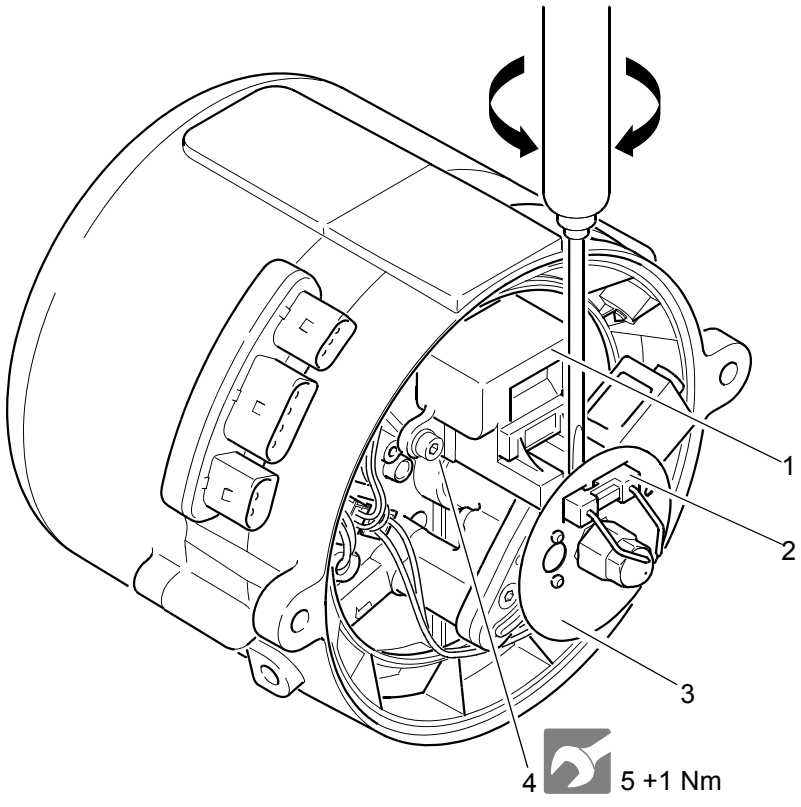


Fig. 804 Removal of the electronic ignition unit / ignition electrode

1 Electronic ignition unit
2 Screw (2)
3 Ignition electrode
4 Atomizer nozzle
5 Disc
6 Solenoid valve
7 Heating element of the nozzle block preheater (optional)
8 Thermostat of the nozzle block preheater (optional)
9 Clamp
10 Fuel pump
11 O-rings (2)
12 Screen
13 Screws (3)
14 Burner housing
15 Control unit
16 Adjustment ring
17 Coupling
18 Screw CU

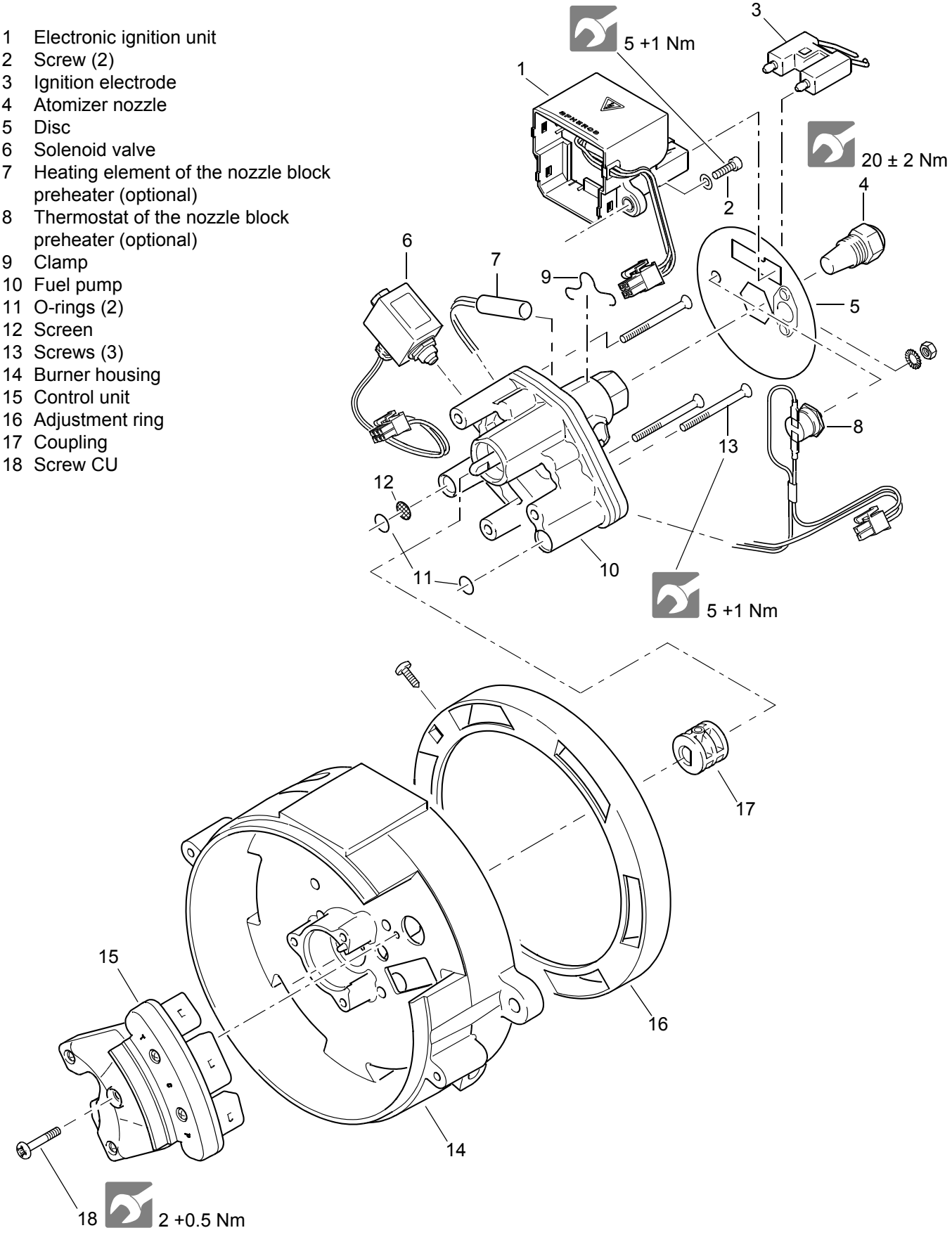


Fig. 805 Components removal and installation

8.7 Control unit removal and installation

Removal
1. Remove burner (see 8.2).
2. Disconnect all inside located plugs (motor, nozzle block preheater, electronic ignition unit, solenoid valve).
3. Remove fuel pump (see 8.8).
4. Remove electronic ignition unit (see 8.6).
5. Remove motor (see 8.5).
6. Remove control unit attaching screw.
7. Remove control unit.

Installation
1. Position control unit.
2. Screw in and tighten control unit attaching screw (18, Fig. 805).
3. Install motor (see 8.5).
4. Install electronic ignition unit (see 8.6).
5. Install fuel pump (see 8.8).
6. Reconnect all inside located plugs (motor, nozzle block preheater, electronic ignition unit, solenoid valve).
7. Install burner (see 8.2).

8.8 Fuel pump removal and installation

NOTE:
Make sure that any fuel leaking is immediately collected, bound and professionally disposed of.

Removal
1. Remove burner (see 8.2)
2. Lift off ignition electrode (2, Fig. 804) from the electronic ignition unit by twisting a screwdriver sideways (see Fig. 804).
3. Remove disc (3).
4. Disconnect the solenoid valve plug (6, Fig. 805) and the optional nozzle block preheater (7) from the control unit (15).
5. Remove screws (13).
6. Pull fuel pump (10) with solenoid valve (6) off and remove it.
7. If applicable, remove the nozzle block preheater (7). For this purpose, remove clamp (9) from the nozzle holder using suitable tools.
8. If necessary, remove the solenoid valve (6) from the fuel pump (10) (see 8.9).

Installation
1. If necessary, attach solenoid valve (6, Fig. 805) to the fuel pump (10) (see 8.9).
2. If applicable, install nozzle block preheater (7) and secure with clamp (9) to the nozzle holder using suitable tools.
3. If required, attach new O-rings (11) and a new screen (12) to the fuel pump (10).
4. Slide the coupling (17) with magnets onto the fuel pump (10) shaft.

ATTENTION:
In order to avoid damage to the O-rings, do not twist fuel pump (10) during assembly.
New screws with coated threads must be used for installing the fuel pump.

5. Align fuel pump (10) with the burner housing (14) and bring it into installation position. Align the coupling with magnets (17) with the burner motor by turning the burner motor shaft.
6. Mount the fuel pump (10) using new screws (with coated threads) (13) and tighten the screws.
7. Connect solenoid valve plug (6) and, if applicable, the optional nozzle block preheater (7) to control unit (15).
8. Fit disc (5) onto the nozzle holder and align it with the flame detector in the control unit (15) and the electronic ignition unit (1).
9. Fit ignition electrode (3).
10. Install burner (see 8.2).

8.9 Solenoid valve removal and installation

ATTENTION:
The solenoid valve must be completely replaced and may not be further dismantled! In case of replacement or assembly and disassembly a new gasket ring must be used.

It is not absolutely necessary to remove the fuel pump to disassemble the solenoid valve.
Make sure that any fuel leaking is immediately collected, bound and professionally disposed of.

Removal
1. Remove burner (see 8.2)
2. Lift off ignition electrode (2, Fig. 804) from the electronic ignition unit by twisting a screwdriver sideways (see Fig. 804).
3. Remove disc (5, Fig. 805).
4. Disconnect the solenoid valve plug (6) from control unit (15).
5. Using suitable tools loosen the hexagon, wrench size 16 (6, Fig. 806) of the solenoid valve (6, Fig. 805) from the fuel pump (10) and unscrew the solenoid valve (6).

.

1	Nut, wrench size 12	4	Core
2	Magnetic coil (coil with cable, plug and plate)	5	Tube
		6	Hexagon, wrench size 16
3	Spring lock washer	7	Lifter
		8	Spring
		9	Stay
		10	Gasket ring

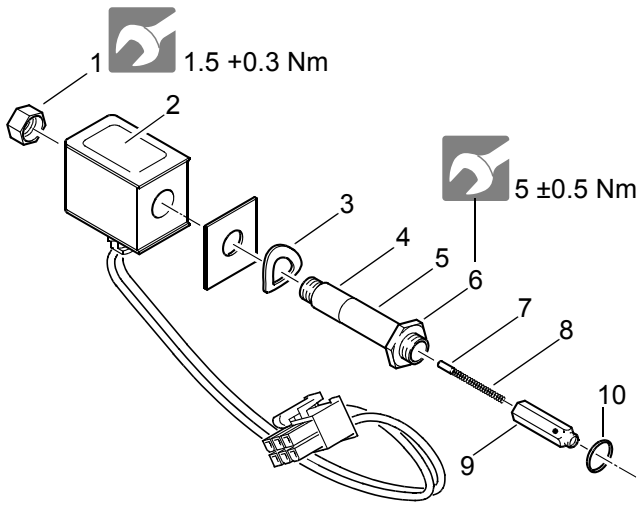


Fig. 806 Solenoid valve

Installation
1. The gasket ring (10, Fig. 806) towards the fuel pump must be replaced. Make sure stay, spring and lifter are correctly assembled, observe installation position (see Fig. 806).
2. Attach solenoid valve (6, Fig. 805) to the fuel pump (10).
3. Using suitable tools, tighten hexagon, wrench size 16 (6, Fig. 806) of the solenoid valve.
4. Connect the solenoid valve plug (6, Fig. 805) to the control unit (15).
5. Fit disc (5) onto the nozzle holder and align with the flame detector in the control unit (15) and the electronic ignition unit (1).
6. Fit ignition electrode (3).
7. Install burner (see 8.2).

ATTENTION:
If the nut, wrench size 12 (1, Fig. 806) was loosened, then it must be tightened with a tightening torque (see Fig. 806) and subsequently secured using locking paint.

8.10 Atomizer nozzle removal and installation

Removal
1. Remove burner (see 8.2).
2. Lift off ignition electrode (2, Fig. 804) from the electronic ignition unit by twisting a screwdriver sideways (see Fig. 804).
3. Remove disc (5, Fig. 805).

NOTE:
We recommend to use nozzle wrench item no. 66971_ for nozzle disassembly and assembly.

4. Unscrew atomizer nozzle (4). If no nozzle wrench is used, a tool must be used to counter on the hexagon of the fuel pump nozzle holder (10).

Installation
1. Screw in the atomizer nozzle (4, Fig. 805) and tighten. If no nozzle wrench is used, a tool must be used to counter on the hexagon of the fuel pump nozzle holder (10).
5. Fit disc (5) onto the nozzle holder and align with the flame detector in the control unit (15) and the electronic ignition unit (1).
6. Fit ignition electrode (3).
7. Install burner (see 8.2).

8.11 Combustion chamber removal and installation

Removal

1. Remove burner (see 8.2).
2. Pull combustion chamber (1, Fig. 807) out of the heat exchanger (2).

Installation

ATTENTION:

When replacing the combustion chamber, ensure that the new combustion chamber corresponds to the heating capacity class of your heating appliance.

1. Slide combustion chamber (1, Fig. 807) fully into the heat exchanger (2) against stop. Pay attention to
   a) the welding seam position, and
   b) the position of cut-outs in the combustion chamber head

NOTE:

– The combustion chamber should be inserted into the heat exchanger in such a way that its welding seam is positioned between 2 and 10 o clock (not upwards!) (Fig. 807).
  A position change during maintenance is permissible and affects the expected service life of the combustion chamber positively.
– Position the cut-outs in the combustion chamber head as shown in Fig. 807.
  Dripping from nozzle fuel is so collected in a reservoir between disc and burner head and will be burned at the next burner operation instead to soil the heater.

2. Install burner (see 8.2).

1 Combustion chamber
2 Heat exchanger
3 Exhaust outlet
4 Stand
5 Coolant inlet
6 Coolant outlet
7 Coolant hose (2x)
8 Hose clamp (2x)

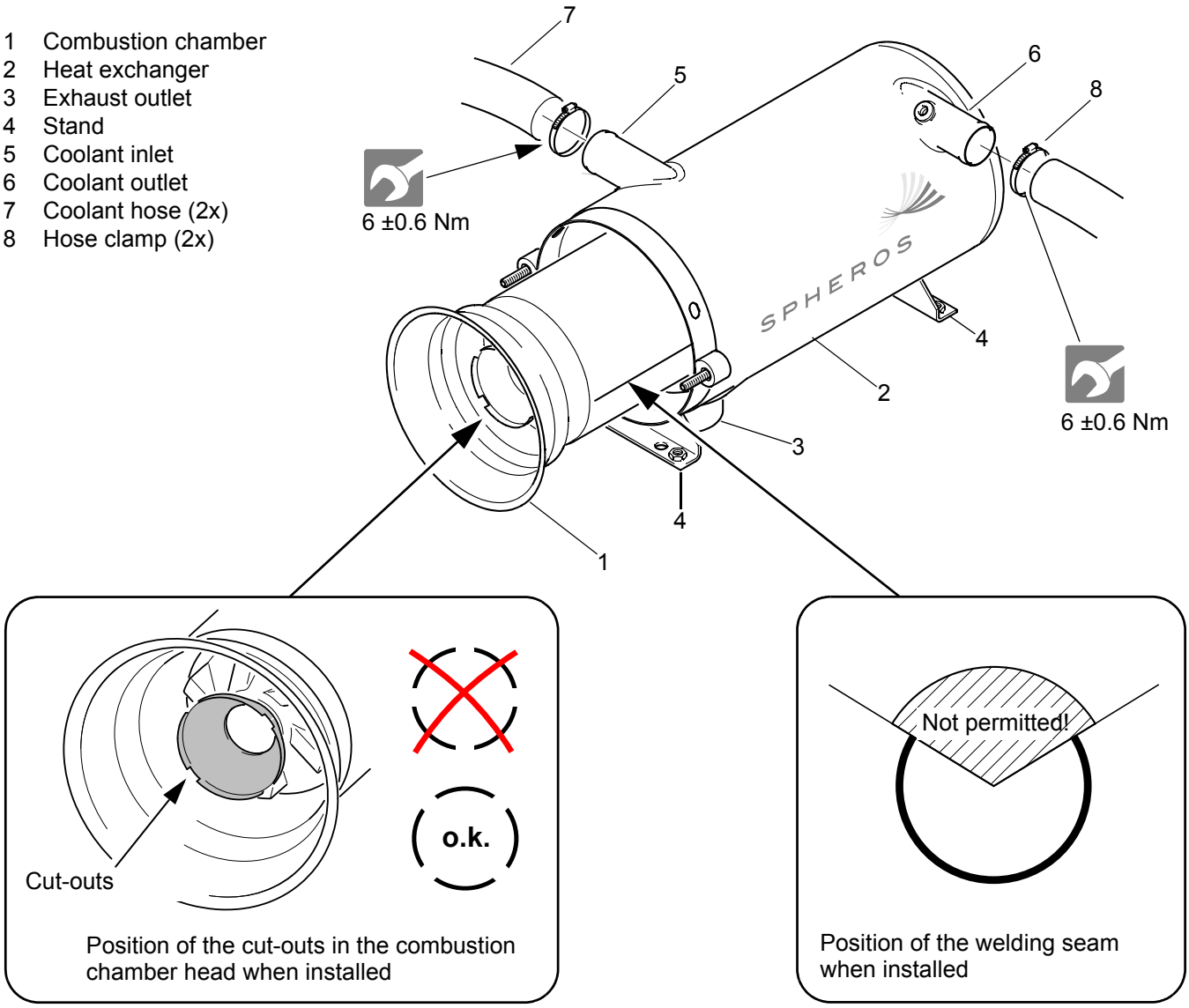


Fig. 807 Combustion chamber/heat exchanger removal/installation

8.12 Heat exchanger removal and installation

Caution!	Risk of burns!

The combustion chamber and heat exchanger can be very hot. If necessary, let them cool down.

Removal
1. Remove burner (see 8.2)
2. If necessary, remove temperature sensor (see 8.3).
3. Pull combustion chamber (1, Fig. 807) out of the heat exchanger (2) (see 8.11).
4. If necessary, loosen the exhaust line clamp on the exhaust outlet (3).
5. If existing, close water taps.

Caution!	Risk of scalds!

Risk of injuries if coolant temperature is increased.

6. Loosen hose clamps on the coolant hoses, pull coolant hoses from the coolant inlet (5) and the coolant outlet (6) and seal with blank plugs. Caution if coolant temperature is increased.
7. Remove screws and washers of the heat exchanger stand (4).
8. Remove heat exchanger from the vehicle.

Installation
1. Bring heat exchanger (2, Fig. 807) into installation position and mount stand (4) using screws, nuts and washers to the vehicle according to the mounting points used.
2. If necessary, secure the exhaust line using a clamp to the exhaust outlet (3).
3. Fit coolant hoses onto the coolant inlet (5) and the coolant outlet (6) and secure with hose clamps.
4. If existing, open water taps.
5. Install burner (see 8.2)
6. Purge coolant circuit (see 8.14.2).

8.13 Heater removal and installation

ATTENTION:

The fuel supply system must be subsequently bleeded (see 8.14.1).
The coolant circuit must be subsequently bleeded (see 8.14.2).

Removal
1. Remove burner (see 8.2)
2. Remove heat exchanger (see 8.12).

Installation
1. Install heat exchanger (see 8.12)
2. Install burner (see 8.2).
3. Bleed fuel supply system (see 8.14.1).
4. Bleed coolant circuit (see 8.14.2).

8.14 Start-up after burner, heater or heat exchanger installation

Coolant and fuel connections must be checked for leak-tightness and tight fit during the test run.
If a malfunction occurs during heater operation, trouble-shooting must be performed (see chapter 5).

8.14.1 Bleeding of the fuel system

If combustion does not start when the heater is started for the first time, the heater must be switched off and on again.
Small air bubbles in the fuel line are released via the atomizer nozzle in the combustion chamber.
Until the fuel line is completely bleeded, flame extinction may occur.
The flame will be re-ignited up to 5 times. After that the heater will be interlocked.

For operation using a long fuel supply line, check valves and/or a fuel filter in the fuel supply line, we recommend to fill the supply line prior to first heater start-up.

8.14.2 Bleeding of the water circuit

NOTE:
The water circuit must be principally bleeded according to manufacturer specification.

Caution!	Risk of scalds!

Risk of injuries if coolant temperature is increased.

The Aquavent 5000 (U4814) and Aquavent 6000S (U4855) circulating pumps may only be switched on for bleeding, after dry operation can be excluded.

The Aquavent 5000S (U4854) and Aquavent 6000SC (U4856) circulating pumps may even in dry operation be switched on for bleeding.

Adjust the vehicle heating system to "warm" and refill coolant.
As soon as it is confirmed that the vehicle engine is filled

with coolant, run vehicle engine with increased idle speed. Once the cooler thermostat opens, switch the vehicle engine off and check the coolant level. Refill coolant as needed.

While the vehicle engine is switched off, switch on the heater with the circulating pump and the vehicle heating fan.
After the engine motor cooled down, the heater must automatically start and stop as soon as the upper switching threshold is reached.

If the heater does not start automatically, it must be verified, whether the heater overheating protection is triggered and the heater is interlocked.

Release the heater (see 4.5) and repeat the bleeding process.

9 Modifications and retrofits

For further optimization the heaters are continuously improved. Units in the field can usually be upgraded or retrofitted. For this purpose respective modification kits will be available. For Information refer to the category ’’Service“ of the Spheros homepage.

10 Packing / storage and shipping

10.1 General

The heater or its components, which are sent to Spheros for inspection or repair, must be cleaned and packaged to ensure that handling, transport and storage will not damage them.

ATTENTION

If a complete heater is sent back, it must be completely drained. Packaging and/or shipping must ensure that no fuel or coolant can leak.

Coolant inlet and outlet fittings as well as the fuel lines must be plugged and sealed using blank plugs.

The temperatures described in Chapter 2 may not be exceeded during storage.

Appendix A

Periodic maintenance

Periodic heater maintenance

The heater should be inspected in periodic time intervals, latest at the beginning of the heating period (time of increased heater usage due to present weather conditions).

The maintenance intervals mentioned below refer to common applications and requirements in omnibuses. If heaters should be used in other vehicles and/or applications, the maintenance intervals may be shortened or extended. In such cases please contact your dedicated Spheros partner for further information.

Inspection / maintenance activities	Important information	Inspection result OK	Inspection result not OK	Measured values Executed repairs
1. Electrical connections				
a) Loosen electrical plug connections to the wiring harness, inspect for oxidation, spray and reconnect after completing point 5.	Use suitable contact spray, e.g. special contact spray (order no. 101322).	☐	☐	
b) Inspect electrical fuses for oxidation and/or contact resistances.		☐	☐	
2. Heat exchanger				
a) Inspect for dark burn marks on the paint (local overheating).	Determine overheating cause as needed (e.g. water circulation system); check overheat temperature limiter.	☐	☐	
b) Inspect for leak marks.		☐	☐	
c) Clean heater exterior and interior.		☐	☐	
3. Fuel system				
a) Inspect fuel lines and connections for leakage.	Ensure connections to fuel flow and return lines are sealed tight!	☐	☐	
b) Replace fuel filter insert with gasket.		☐	☐	
c) If available, open fuel shut-off valves	Re-tighten screw connections and hose clamps.	☐	☐	
d) Fuel pump and fuel lines.	Replace pump and pipes every 5 years.	☐	☐	
NOTE: Observe technical information if biodiesel or FAME is used!				
e) Replace fuel screen with gasket in the pump.	**Observe technical biodiesel / FAME information!**	☐	☐	
4. Burner head				
a) Inspect combustion air intake opening for clear passage.		☐	☐	
b) Inspect hood for damage.	Replace damaged hood	☐	☐	
c) Inspect housing interior for fuel accumulations caused by leaking.		☐	☐	
d) Clean flame detector inspection glass.		☐	☐	
e) Inspect condition of the ignition electrodes.	Replace bent electrodes.	☐	☐	
f) Replace atomizer nozzle (wear part).	In case of coke build-up shorten fuel filter replacement interval.	☐	☐	
g) Check nut-and-washer assemblies M8 (2ea) for burner attachment for tight fit (torque to 7.5 +1 Nm) and secure with locking paint.		☐	☐	
5. Exhaust system				
a) Inspect exhaust line for clear passage, clean as needed.		☐	☐	
b) Remove combustion chamber from heat exchanger, inspect both parts for damage and contamination, clean and replace as needed.		☐	☐	
c) Insert combustion chamber and mount burner head. Ensure tight connection to heat exchanger.		☐	☐	
d) Reconnect electrical plug contacts.		☐	☐	
6. Water system				
a) Clean filter insert, if available.		☐	☐	
c) Open water shut-off valves, if available.		☐	☐	
7. Functional check				
a) Open shut-off valve of the return line, if available.		☐	☐	
b) Check heater functionality.	after at least 10 min. heater operation.	☐	☐	
c) Check for smoke development during purge cycle, replace nozzle as needed.		☐	☐	

memos

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