SPHEROS
a Valeo brand

Water Heater

Workshop Manual

Thermo S 160
Thermo S 230
Thermo S 300
Thermo S 350
Thermo S 400

with Control Unit 1586

Rev. 02/2017
Id. No. 11114913B

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 S 160, S 230, S 300, S 350 und S 400.

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
- Operating Instructions for the Spheros Thermo Test, further referred to as STT Diagnosis

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 proce-dures.

1.6.1 General safety regulations

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

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

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

NOTE:

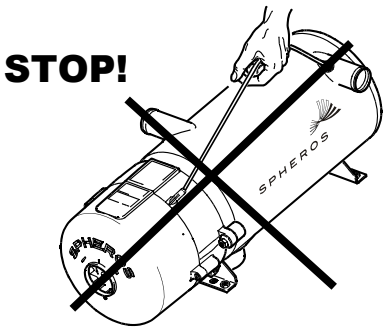
The Thermo S Operating and Service Instructions contain safety instructions and regulations to be followed for safe operation of the heater.

The Thermo S 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.

Tabelle 701 Technical data

Heater		Thermo S 160	Thermo S 230	Thermo S 300	Thermo S 350	Thermo S 400
ECE type permit number E1 122R 00		0208	0226	0227	0228	0225
Design		High-pressure atomizer				
Heat flow rate (at 20°C ambient temperature)	kW (kcal/h)	16 (13 800)	23 (20 000)	30 (26 000)	35 (30 000)	40 (34 000)
Fuel		Diesel / light fuel oil				
Fuel consumption	kg/h	1.6	2.5	3.0	3.6	4.1
Nominal voltage	V =	24				
Operating voltage range	V =	20...30				
Electrical power consumption at 24 V *	W	50	65	90	120	180
Max. permissible combustion air intake temperature	°C	+ 85				
Permissible ambient temperature during operation	°C	-40...+ 100				
Permissible storage temperature	°C	-40...+ 110				
Permissible operating overpressure	bar	max. 2.0				
Heat exchanger filling volume	l	1.8				
Minimum water flow **	l/h	1400	1900	2400	2700	3200
Minimum circulation volume	l	25.0				
CO_2 in exhaust at nominal voltage	Vol %	9.5 + 1.5				
Heater dimensions (tolerance ± 3 mm)	mm	Length 600 / Width 247 / Height 220				
Weight	kg	18.4	18.8			

* without circulating pump

** Minimum water flow at coolant temperatures above 50°C
Below 50°C a lower water flow is permitted, if the occurence of vapor bubbles due to local overheating safely can be excluded.

2.1 Electrical components

Control unit, circulating pump, solenoid valve, electronic ignition and the digital timer are designed for 24V nominal voltage. Motor nozzle block preheater and temperature sensor voltages are controlled by the control unit.

NOTE:
Circulating pumps must be assigned to the heaters according to the flow resistance in the coolant circulation system. Voltages directly applied to the burner motor for testing purposes may not exceed 12 V.

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 Assemblies and component descriptions

The Spheros Thermo S 160, S 230, S 300, S 350 and S 400 water heater systems are used in conjunction with the vehicle heating system

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

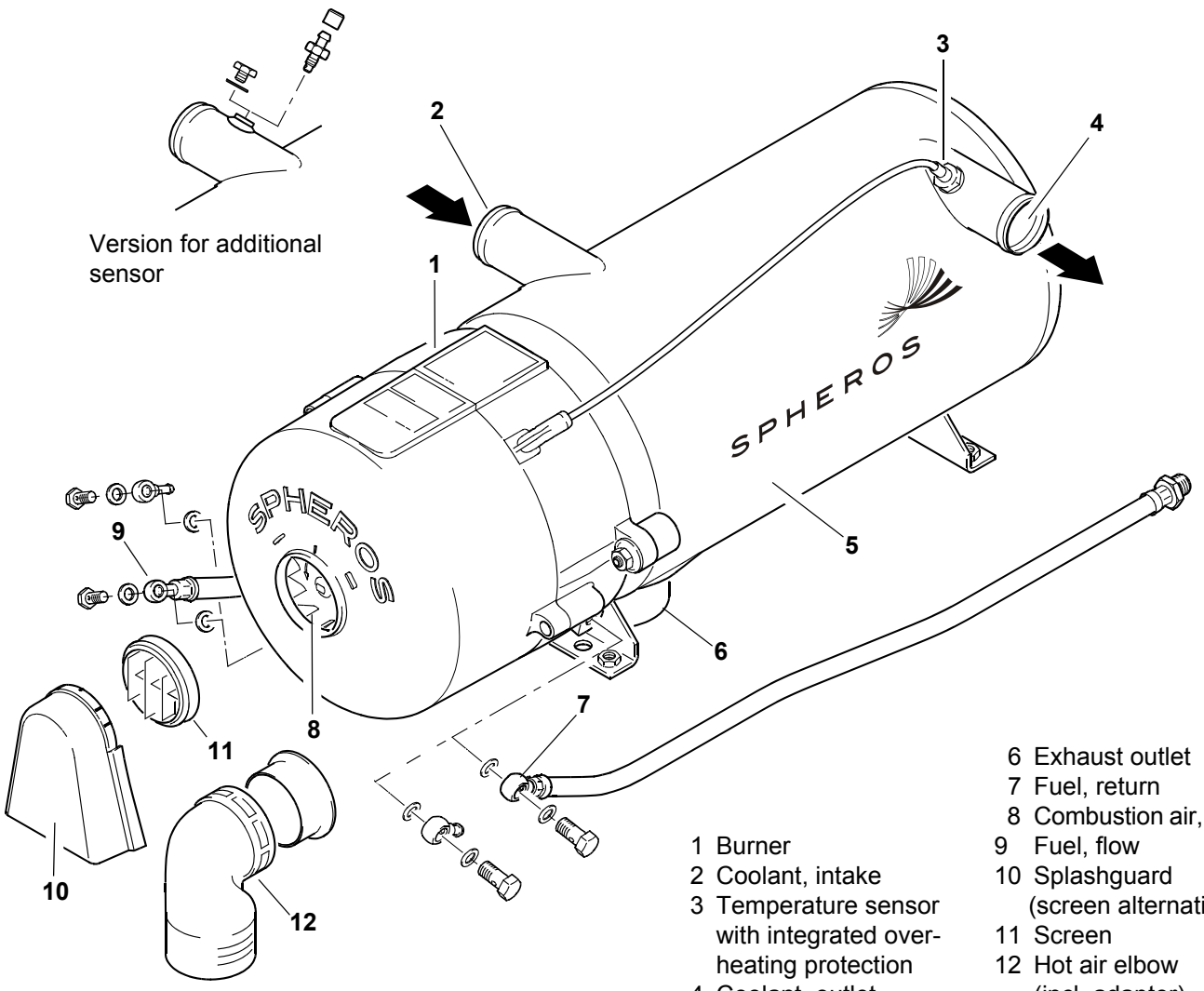
The water heater operates independently from the vehicle engine and is connected to the cooling system, the fuel system and the electrical system of the vehicle. It is bolted down to the vehicle chassis or is secured using an additional cross beam.

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 (cyclic operation). The control unit controls heater activation and deactivation based on the temperature sensor signals.

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

– Burner
– Combustion chamber
– Heat exchanger

A circulating pump is externally installed in the system, or for compact devices directly on the heater.



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

3.1 Burner

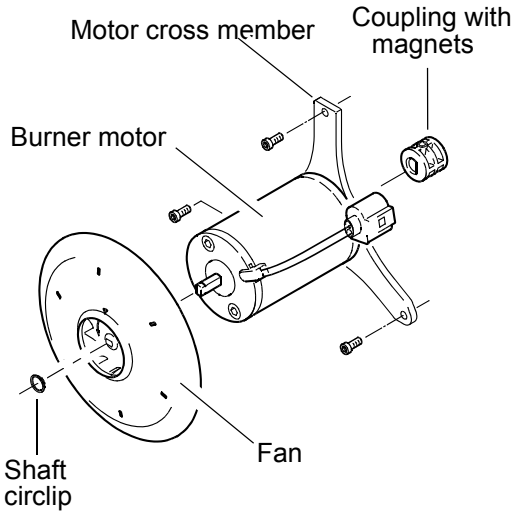
The burner consists of components

- Burner motor
- Combustion air fan
- Fuel pump with solenoid valve and atomiser nozzle
- Electronic ignition unit with ignition electrode
- Nozzle block preheater, optional
- Control unit with flame detector
- Disc with inspection glass
- Adapter wiring harness as interface to the temperature sensor system

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, fan and motor cross member. 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.



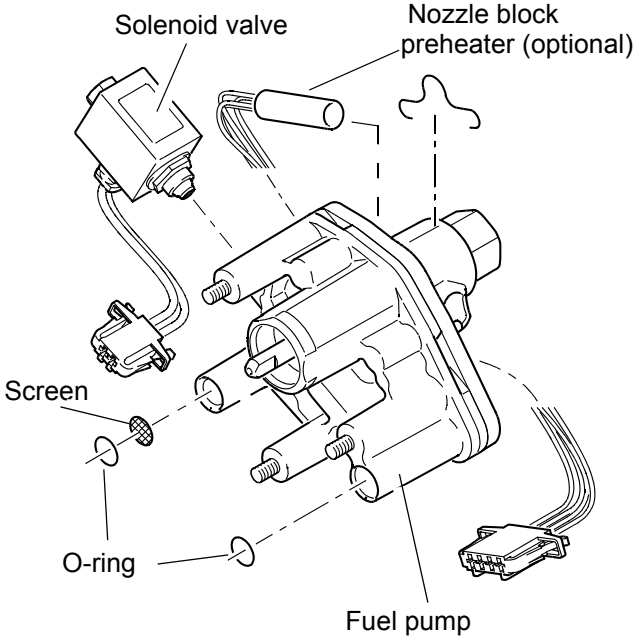
Two different motors are assigned to the different heating capacity classes of the Thermo S series. The respective heating capacity classes are indicated on the motor. In addition the motors are differentiated by colour.

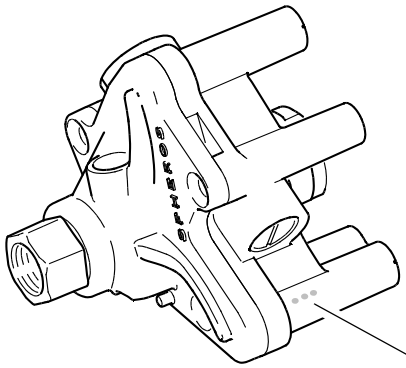
- 16 kW - 30 KW: Motor housing colour: silver
- 35 kW - 40 KW: Motor housing colour: black

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 atomised via the atomiser nozzle.
The solenoid valve integrated into the fuel pump opens and closes the fuel supply to the atomiser nozzle.
Three different fuel pumps are assigned to the different heating capacity classes of the Thermo S series.
These are identified by the heating capacity class specification as well as colour dots:

- 16 KW: 1 colour dot
- 23-35 KW: 2 colour dots
- 40 KW: 3 colour dots





The fuel pump can be used in dual-line operation (fuel supply and return line).

If the heater is operated with

– a long fuel supply line
– check valves in the fuel supply and return line
– a fuel filter in the fuel supply line
– single-line operation

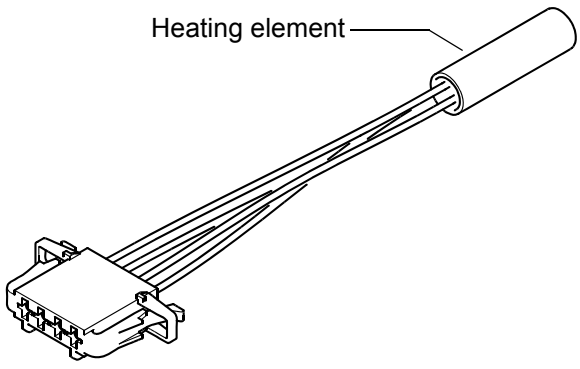
the fuel supply line must be filled prior to first heater start-up (see 8.14.1).

3.1.3 Nozzle block preheater

In case of very low temperatures fuel may exhibit severely modified viscosity. Due to insufficient fuel atomisation 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 atomisation improved.
The control unit defines the preheating time depending on vehicle electrical system voltage and starting temperature.

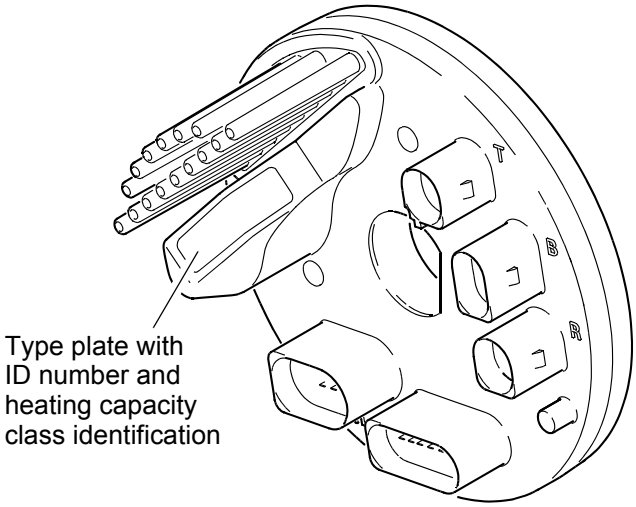
The use of the nozzle block preheater is optional. It is possible to retrofit this capability without modifications to the control unit.



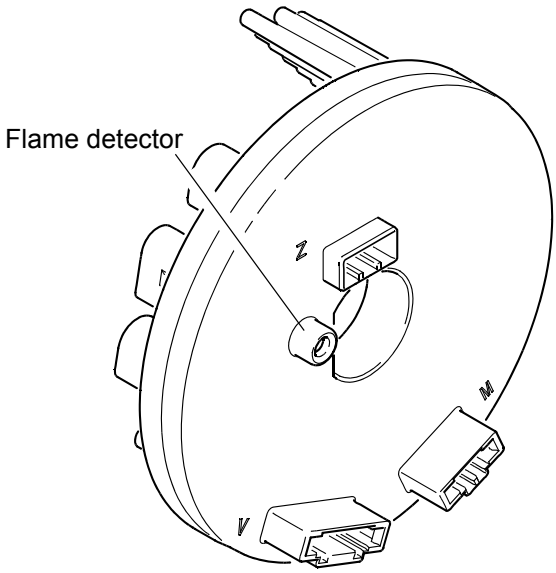
Nozzle block preheater

3.1.4 Control unit

The control unit 1586 ensures the operating sequence and burner operation monitoring.
The flame detector is integrated into the control unit.
Different control units are assigned to the different heating capacity classes.
The control units are assigned via the ID number and the performance class indicated on the type plate of the control unit.

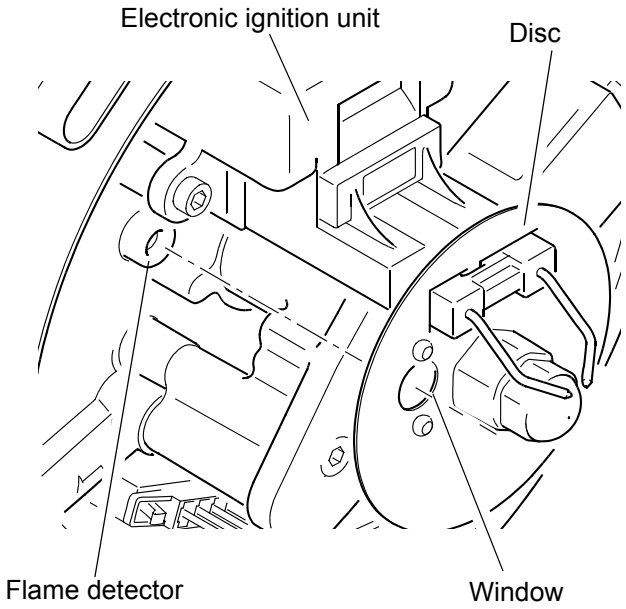


Control unit 1586



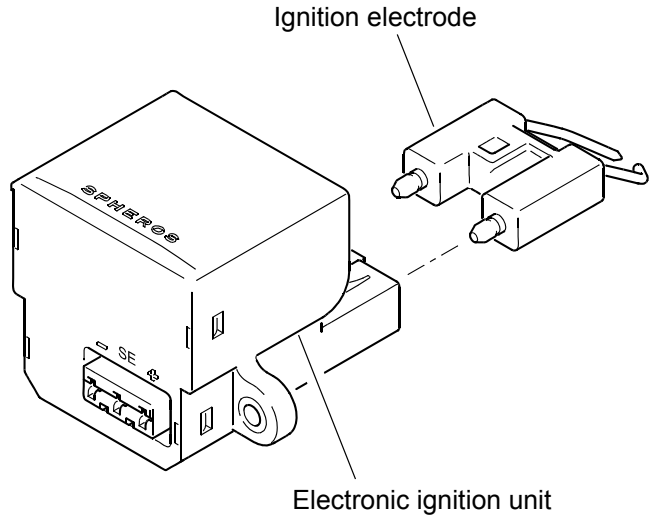
3.1.4.1 Flame detector

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.



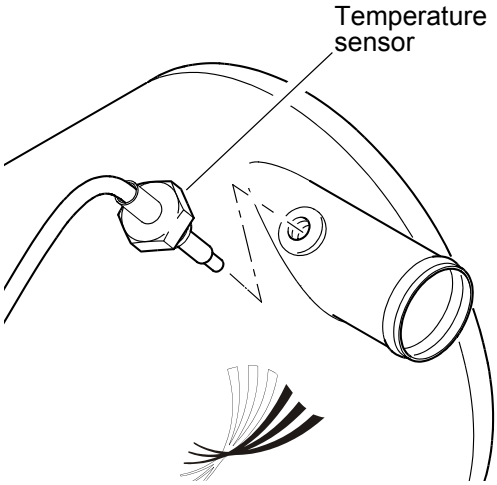
3.1.5 Electronic ignition unit with ignition electrodes

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

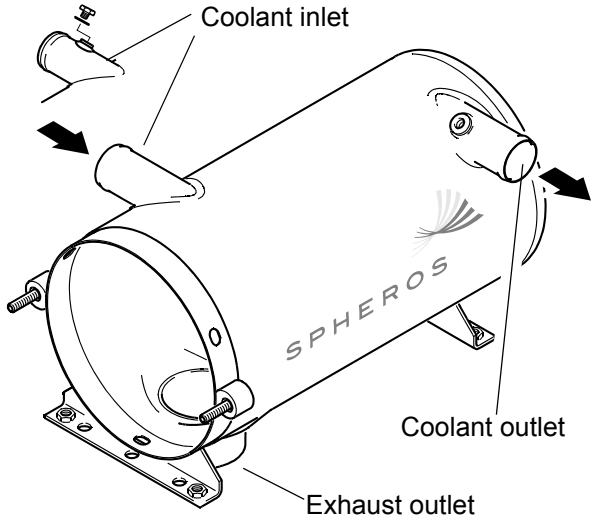
The water temperature sensor captures the coolant temperature at the heat exchanger outlet as electrical resistance. This signal is transmitted to the control unit, where it is processed.
The overheating protection integrated into the temperature sensor is responsible for temperature limitation.
Similar 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 135°C heater deactivation and interlocking is initiated.
The procedure to release the heater interlock is outlined in para. 4.6.1.



ATTENTION
To remove the burner head, first remove the hood, disconnect the temperature sensor plug and remove the cable grommet from the burner housing. Then the burner head can be disassembled.

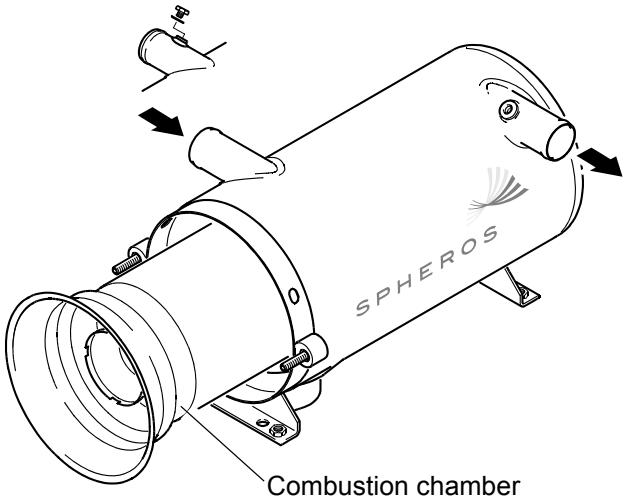
3.2 Heat exchanger

The heat exchanger transfers the heat generated by combustion to the coolant circulation system.
Depending on the system integration a heat exchanger with or without thread in the coolant inlet socket can be installed.



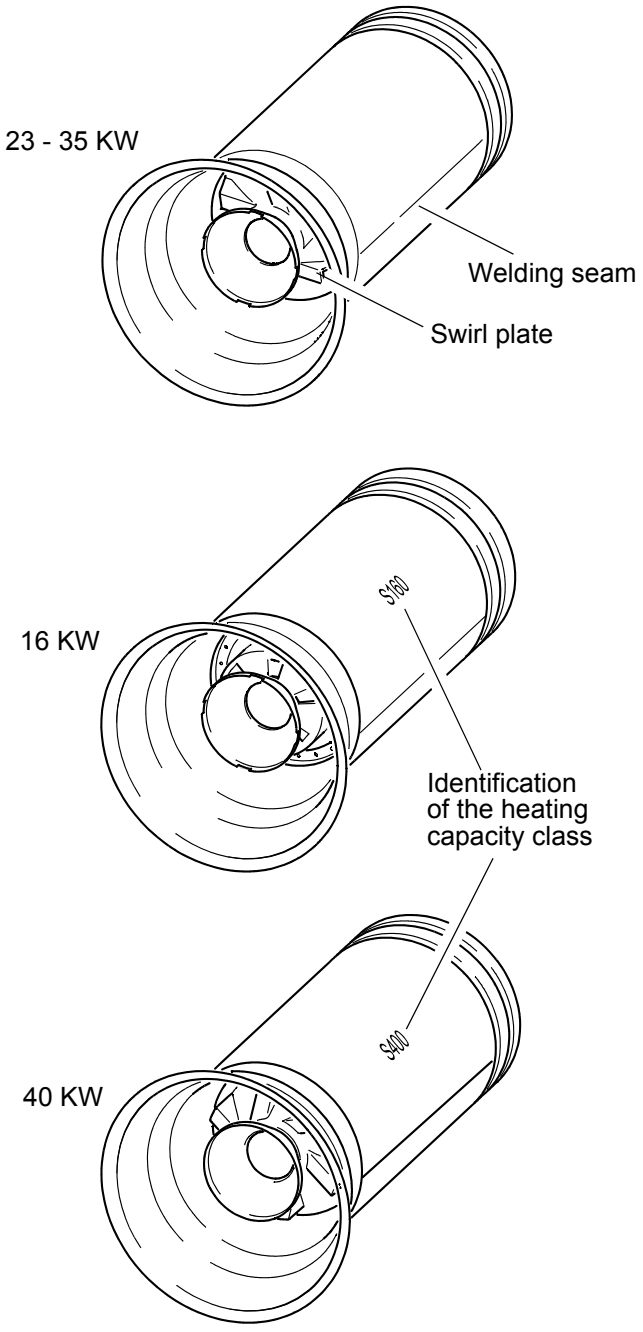
3.3 Combustion chamber

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.



Three different combustion chambers are used for heaters of the Thermo S series. Deviating from the standard combustion chamber variant for Thermo S 230, S 300 and S 350, the Thermo S 160 is equipped with a combustion chamber with a sheet metal swirler and the Thermo S 400 is equipped with a burner pipe with increased wall thickness (1.5 mm).

The combustion chambers of Thermos S 160 and Thermo S 400 are each fitted with a stamping to distinguish the individual combustion chambers.



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)	12 or 24	10…14 or 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

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

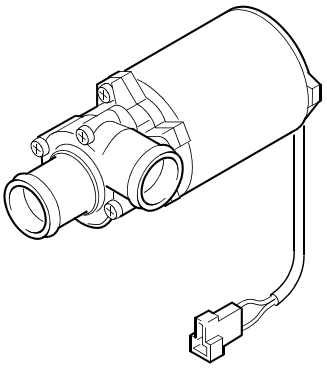
3.4.1 Aquavent 5000 (U4814) and Aquavent 5000S (U4854) circulating pumps

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

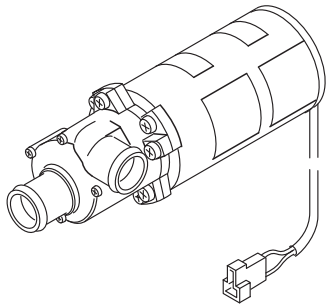
NOTE:
Aquavent 5000 (U4814) with floating-ring type shaft seal.
Aquavent 5000S (U4854) magnetic drive (no seal)

ATTENTION:

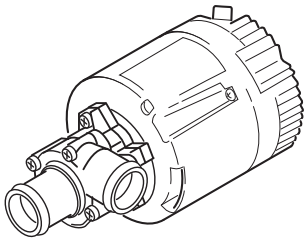
The circulating pump motor is not equipped with an internal inverse-polarity protection.



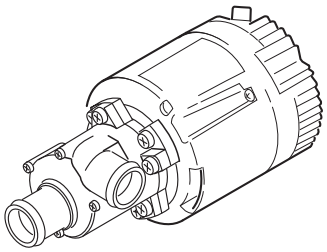
Aquavent 5000 (U4814)



Aquavent 5000S (U4854)



Aquavent 6000C (U4855)



Aquavent 6000SC (U4856)

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)

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
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 temperature switch switches the integrated filter heating on at a temperature of $\leq 0.5 \pm 2.5$ °C and switches it off at a temperature of $\geq 5.5 \pm 2.5$ °C.

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 plastic coupling. The fan produces the required combustion air, the combustion air volume is impacted by the burner motor speed.
The speed is monitored by a sensor in the control unit, which analyses the changing magnetic field of the magnets in the coupling.

The speed required for the CO_2-content is determined during first calibration at Spheros and is stored in the control unit.
In a maintenance event the workshop can adjust the CO_2-setting using the STT diagnosis (Spheros-Thermo-Test-Diagnosis) (see 4.3).

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 low temperatures, 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 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. The heater is switched on, when the temperature falls short of a lower temperature threshold, and is switched off, if the upper temperature threshold is reached (see Table 401).

The switching thresholds depend on the heater variant and the heating operation type. They cannot be changed and are programmed into the control unit.

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

If the specified minimum burning duration is not reached, the switching thresholds will be reduced. This protects the heater against sooting of the heat exchanger.

An operating display is available for monitoring the operating status. A flame indication can be optionally installed.
The operating display is also used to output error messages in flash code.
It is also possible to read the flash code via the two-pin plug in the heater wiring harness (see 4.7 and 5.3).
Use max. 2W lamps.

Table 401 Standard switching thresholds

	Standard
Lower switching threshold: auxiliary heating in °C	78
Upper switching threshold: auxiliary heating in °C	85
Lower switching threshold: normal mode parking heating in °C	70
Upper switching threshold: normal mode parking heating in °C	85
Lower switching threshold: saving mode 1 parking heating in °C	55
Upper switching threshold: saving mode 1 parking heating in °C	70
Lower switching threshold: saving mode 2 parking heating in °C	45
Upper switching threshold: saving mode 2 parking heating in °C	60

NOTE:
Switching thresholds may deviate per customer.

4.2 Operational heater sequence

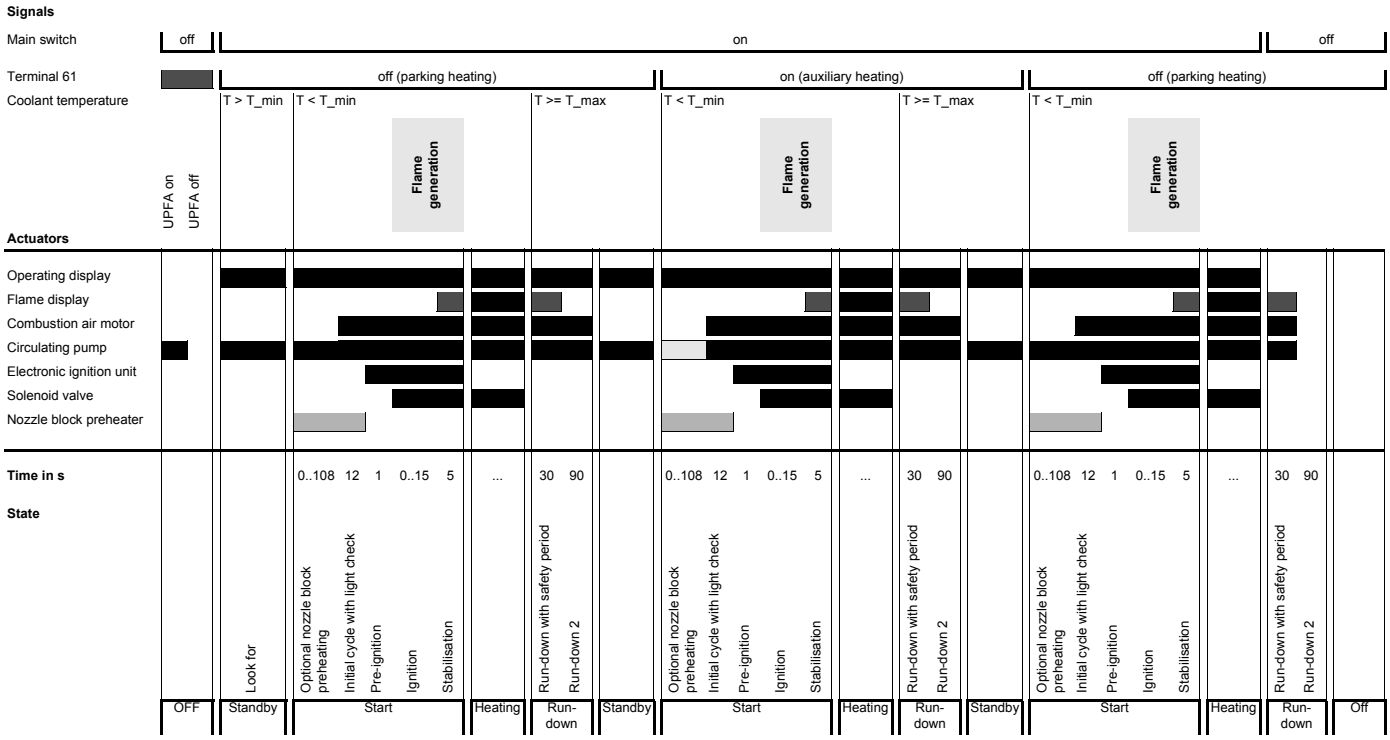


Fig. 401 Operational sequence

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 approx. 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.
A few seconds after a flame is detected, the control unit switches the electronic ignition unit off. Until then the flame is stabilised. The heater is not yet in heating mode.

With optional nozzle block preheater:
The integrated temperature sensor determines the temperature on the nozzle holder as soon as the initial cycle starts. Starting at a temperature of < 5°C the nozzle block preheater is switched on. Depending on the determined temperature and the vehicle electrical system voltage the preheating time is determined. The duty cycle is limited to a maximum of 120 seconds.
The burner motor does not run during the entire preheating time. It starts latest 12 seconds prior to expiration of the determined preheating time during initial cycle.
The initial cycle time can be extended to a maximum of 120 seconds.
The further sequence takes place as described.

4.2.2 Heating operation

After the flame is stabilised, the heater is in controlled (normal) operation.
Depending on the coolant temperature, the coolant temperature is maintained at one level by switching the burner alternately on and off.

Once the upper switching threshold is exceeded, heating operation is finished and run-down initiated.
The solenoid valve is closed, the flame expires, however the combustion air fan and circulating pump continue running.
The run-down 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.

Different switching thresholds are defined for different heater operating modes.
The switching thresholds are selected depending on the present condition and the selected heating operation.
The following switching thresholds may be applied.

- Parking heating mode and auxiliary heating mode
- Gradient evaluation
- Minimum combustion period (also called hysteresis adaptation)
- Saving mode 1 and saving mode 2

The switching thresholds can be obtained from Table 401.

4.2.2.1 Auxiliary heating mode and parking heating mode

The control unit received the information, whether the vehicle engine is running or not, from terminal D+/+61.

If terminal D+/+61 is connected and the vehicle engine is running, the switching thresholds in auxiliary heating mode are higher than in parking heating mode with the engine not running.
In that case a saving mode is activated in parking heating operation.

If terminal D+/+61 is not connected, then there is no distinction. The heater always runs in parking heating operation.

4.2.2.2 Saving modes

Two different saving modes are programmed in the control unit.
Saving mode 1 and saving mode 2 exist (see Table 401).
In saving mode 1 the switching thresholds are higher than in saving mode 2.

If saving mode is activated, the controlled temperatures in the heating system are maintained at a low temperature level. The lower and upper switching threshold are reduced.

Due to lower radiation loss the fuel consumption can be reduced for a lower heat demand (e.g. warmer mode).
The heater burner output is not reduced.

In auxiliary heating mode (signal from terminal D+/+61) saving mode is automatically deactivated (see 4.1).

4.2.2.3 Gradient evaluation

In case of low coolant flow or poor coolant circuit venting the temperature quickly increases in heating operation.

The control unit recognises 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.

4.2.2.4 Minimum combustion period

A minimum burner combustion period of 120 second is targeted.

For ambient and operating conditions this target is not always achieved.
In order to achieve the minimum combustion period, the lower switching threshold is variably adjusted by the control unit.

This process is also called hysteresis adaptation and is applied in parking heating operation as well as auxiliary heating operation.

If the combustion period falls short of the minimum combustion period, the lower switching value is lowered by 1K for the following combustion process.
The upper switching threshold remains as is.
This can be repeated until the minimum combustion period is reached or the lower switching threshold is reduced by 5K.
Further lowering is not possible.

Following a combustion process, where the required minimum combustion period was reached, the lower switching value is reset to its original value.

4.2.3 Switching off

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

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

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

4.3 Diagnosis interface and STT diagnosis

Heaters of the Thermo S series support diagnosis capabilities. Using the STT diagnosis adapter, STT diagnosis and a PC, the heaters in a vehicle can be checked. For this purpose the STT diagnosis adapter is connected to the diagnosis interface in the heater wiring harness, and to a PC (see Fig. 403).
Next, STT diagnosis is started on the PC and the connection to the heater control unit is established.

4.3.1 Test plug

During tests with the STT diagnosis menu "component test", the test plug is plugged directly into the control unit of the heater after removal of the hood instead of the temperature sensor.

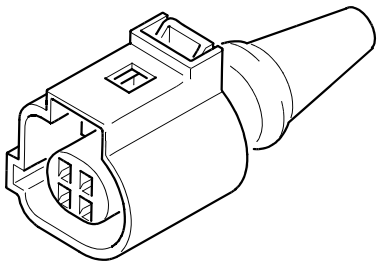


Fig. 402 Test plug

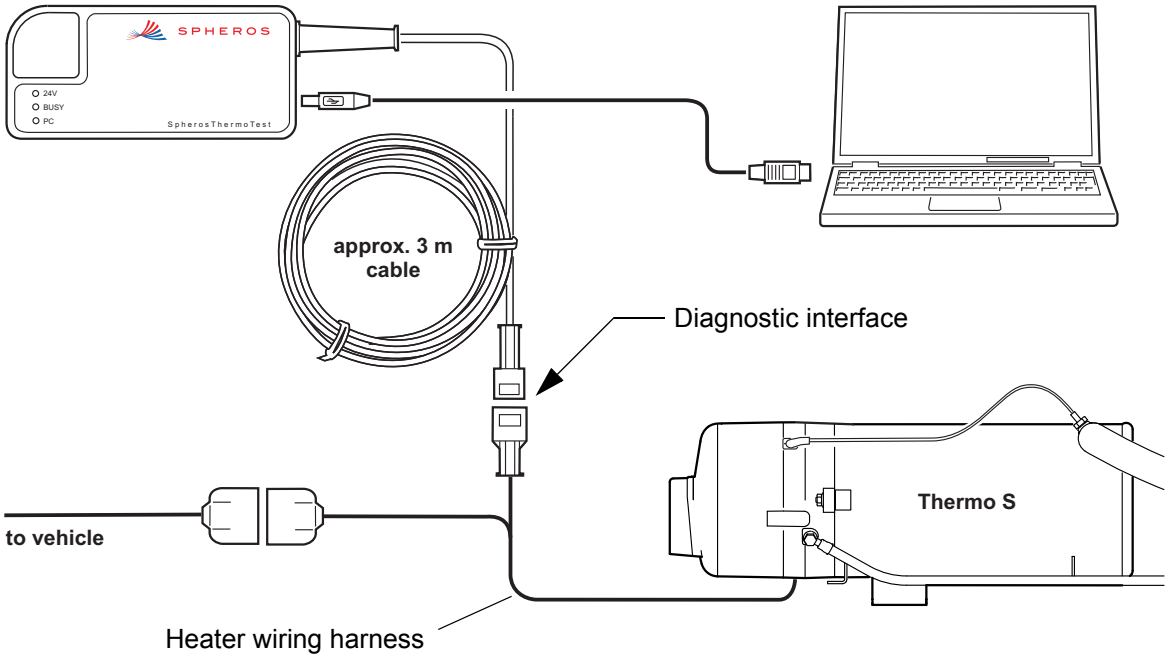


Fig. 403 STT diagnosis connection to the heater

NOTE

For protection against moisture and contamination ensure that the diagnosis interface is sealed using protective caps, if not in use.

The latest STT diagnosis software can be found in the Internet on the Spheros homepage under Service / Technical Documents.

4.4 Malfunction interlock and heater interlock

Malfunction interlocks and heater interlocks are distinguished.
Each malfunction interlock and heater interlock is stored in the control unit.

The heater should be protected against 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.

4.5 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 timing, no run-down or a 120 seconds run-down will be executed.
Flash impulses are outputted via the operation indicator (see 5.3).

In case of several sequential malfunction interlocks a heater interlock is initiated (see 4.6).

4.5.1 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 run-down.

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

If the circulating pump is externally actuated, it will continue operating.

Malfunction criteria:
- Short circuit and/or interruption of electrical components:
  - Burner motor (stops immediately)
  - Circulating pump
  - Electronic ignition unit
  - Optional nozzle block preheater
- 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.
- Burner motor speed signal faulty.
- 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 (run-down only, no malfunction interlock).

4.5.2 Malfunctions during heater operation

NOTE:
In case of malfunctions during heater operation, a 120 seconds run-down will be executed first. Subsequently the heater status is switched to malfunction interlock.
If the circulating pump is externally actuated, it will continue operating.

Malfunction criteria:
- Short circuit and/or interruption of electrical components:
  - Burner motor (stops immediately)
  - Circulating pump.
- Water temperature greater than the upper switching threshold.
- Temperature sensor delivers unacceptable temperature values.
- Heater operation outside the permissible temperature range.
- Burner motor speed signal faulty.
- 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 (run-down is applied, but no malfunction interlock).
- Reaching the max. number of shortfalls of the minimum combustion duration.
- Control unit malfunction.

4.5.3 Malfunctions during run-down

NOTE:
If the circulating pump is externally actuated, it will continue operating.

Malfunction causes:
- Short circuit and/or interruption of electrical components:
  – Burner motor (stops immediately)
  – Circulating pump.
- Heater operation outside the permissible temperature range.
- Motor speed signal faulty.
- 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 (run-down is applied, but no malfunction interlock).
- Control unit malfunction.

4.5.4 Malfunction interlock release

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

4.5.5 Deleting the error using the diagnosis

The detected error is stored in the error memory and can be read out using the STT diagnosis.
It is possible to delete the stored error using the STT diagnosis (see 4.3).

4.6 Heater interlock

The heater interlock overrides the standard malfunction interlock.

If the heater interlock is active, neither start nor run-down 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 4.6.1).

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 run-down.
The heater is in heater interlock state.
The burner motor stops immediately or does not start.

Besides that a run-down between 30 seconds and up to 120 seconds is performed depending on error type and timing.
Subsequently the heater status is switched to heater interlock.
If the circulating pump is externally actuated, it will continue operating.

Heater interlock causes:
- Short circuit and/or interruption of electrical components:
  – Solenoid valve
  – Flame detector
  – Overheating protection
  – Water temperature sensor.
- The flame is not expired within 30 seconds after the run-down was started (Burner motor stops).
- Overheating protection triggered.
- Control unit error
- Repeated malfunctions
- Repeated flame interruptions

4.6.1 Heater interlock release

ATTENTION:

A distinction is made between heaters with standard control (pre-selection timer, switch, etc.) and heaters controlled via a CAN bus.

4.6.1.1 Heaters with standard control

To release the heater interlock the heater must be disconnected one time from the vehicle electrical system.

Heater interlock release procedure:
1. Remedy the cause of the heater interlock.
2. Switch on the interlocked heater.
3. Disconnect the switched on heater from the vehicle electrical system.
4. Reconnect the switched on heater to the vehicle electrical system.

NOTE:
The heater starts after reconnection to the vehicle electrical system automatically.
The heater can be switched off during initial cycle.

Heater interlock release using the STT diagnosis:
1. Connect the heater with the STT diagnosis and read out the error memory.
2. Correct the cause of the heater interlock.
3. Disconnect the heater from the vehicle electrical system.
4. Reconnect the heater to the vehicle electrical system.
5. Clear the error memory using the STT diagnosis.

4.6.1.2 Heaters with control via CAN bus

Heater interlock release by pulling the fuse:

ATTENTION:

It is not allowed to disconnect the heater from the vehicle mains by pulling the heater connector under power.

1. Disconnect the **switched-on** and interlocked heater from the vehicle electrical system for > 10 seconds by pulling the **vehicle-mounted heater fuse** (F1).
2. Remedy the cause of the heater interlock.
3. Connect the switched-on heater to the vehicle electrical system by inserting the vehicle-mounted fuse (F1).
4. Disconnect the switched-on heater again from the vehicle electrical system for > 10 seconds

Heater interlock release using the STT diagnosis:

ATTENTION:

It is not allowed to disconnect the heater from the vehicle mains by pulling the heater connector under power.

1. Read out the heater error memory using the STT diagnosis.
2. Disconnect the **switched-on** and interlocked heater from the vehicle electrical system for > 10 seconds by pulling the **vehicle-mounted heater fuse** (F1).
3. Remedy the cause of the heater interlock.
4. Reconnect the heater to the vehicle electrical system by re-inserting the vehicle-mounted fuse (F1).
5. Clear the error memory using the STT diagnosis.

4.7 Error output

If the heater is equipped with the standard timer, an error output is displayed on the digital timer after a malfunction occurs.
It is also possible to output an error via flash code.
An error is outputted this way via the operating display or via the two-pin plug in the heater wiring harness (see 5.3).
Furthermore it is possible to output an error via STT diagnosis (see 4.3).

5 Troubleshooting and error correction

5.1 General

This section describes troubleshooting and error correction for Thermo S 160, S 230, S 300, S 350 and S 400 heaters.

Warning!	Danger to life and health!

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

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 must be replaced in currentless state.
A properly dimensioned fuse must be inserted (see chapter 6 Schematic 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 F2 triggered.	Short circuit in the circulating pump or in the supply cable to the heater.
Fuse F3 triggered.	Short circuit in the supply cable to the heater/ burner motor/ nozzle block preheater (if installed).
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 surfaces (outside). • 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. • 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

NOTE:
If the heater is equipped with a standard timer, after a malfunction appears on the display an error message.

An further possibility is the output of a flash code via a lamp which is connected to the two-pin plug on the heater wiring harness.

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 Tabelle 502.

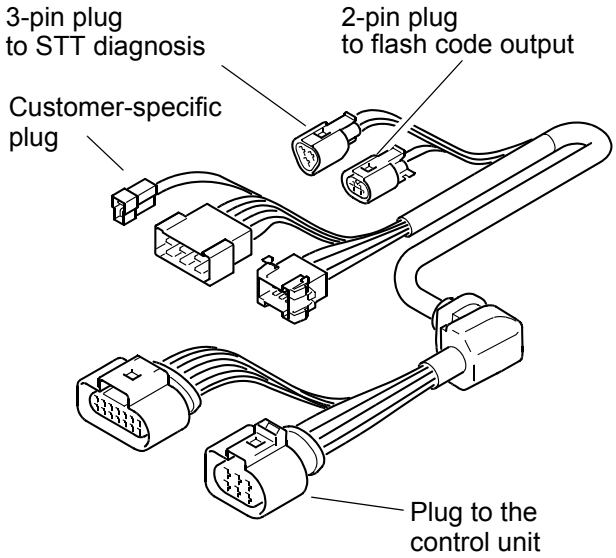


Fig. 501 Standard Thermo S heater wiring harness

Tabelle 502 Error and flash codes

Error description	Flash code
Control unit error (e.g. incorrect checksum, no EOL programming)	0
No start within safety period	1
Flame interruption in burner operation, repeated starts unsuccessful	2
Low voltage	3
Extraneous light (flame detector "Bright" prior to ignition) **or** (flame detector "Bright" in run-down 2)	4
Flame detector short circuit after terminal 31 **or** interruption or short circuit after terminal 30	5
Coolant temperature sensor short circuit after terminal 31 **or** interruption **or** short circuit after terminal 30	6
Coolant temperature sensor / overheating protection defective	6
Overheating protection temperature sensor short circuit after terminal 31 **or** interruption **or** short circuit after terminal 30	6
Solenoid valve short circuit after terminal 31**or** interruption **or** short circuit after terminal 30	7
Motor short circuit after terminal 31 **or** interruption **or** fuse F1 defective **or** short circuit after terminal 30	8
Circulating pump short circuit after terminal 31 **or** interruption **or** short circuit after terminal 30	9
Overheating protection triggered	10
Electronic ignition unit short circuit after terminal 31 **or** interruption **or** short circuit after terminal 30	11
Heater interlock - release required (caused by repeated malfunctions or repeated flame interruptions)	12
Nozzle block preheater sensor short circuit after terminal 31 **or** interruption **or** short circuit after terminal 30	13
Nozzle block preheater heating element short circuit after terminal 31 **or** interruption **or** short circuit after terminal 30	13
Minimum combustion period undercut several times	14
Faulty speed signal	15

5.4 Error symptoms during functional tests with malfunction code output or diagnosis

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 4.6.1.

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"

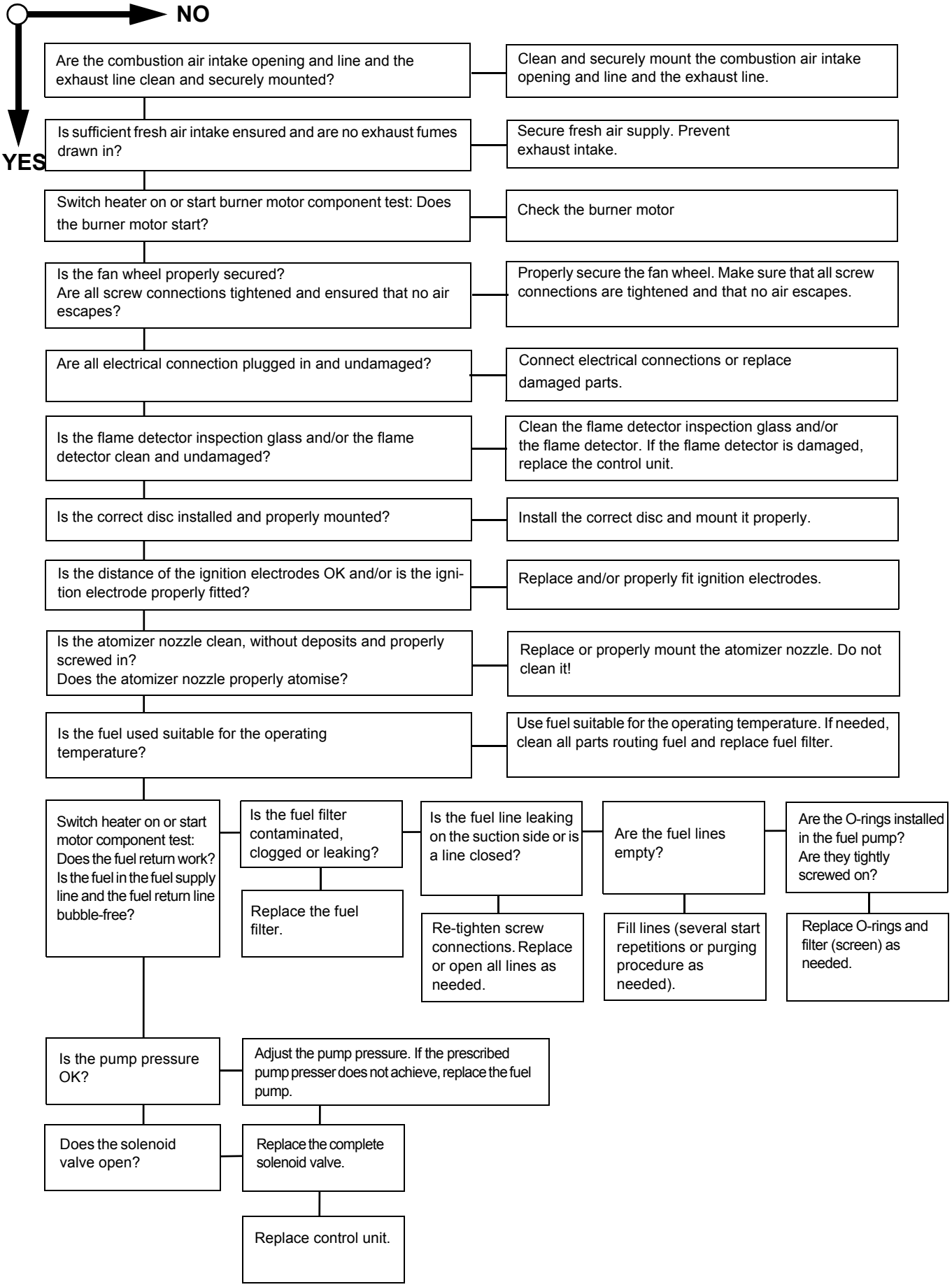
If due to a malfunction flame interruption occurs during heating operation five times in a row, the heater will be interlocked.
No further start attempts will be tried.
The heater interlock overrides the standard malfunction interlock.

The procedure for releasing the heater interlock can be found in point 4.6.1.

Flame Interruption Counter (FIC):
The error counter flame interruption is set after 40s burning operation without malfunction or a successful burning cycle to 0. Reaches the FIC the lock-out threshold (standard 5 times), the heater goes into the heater interlock.

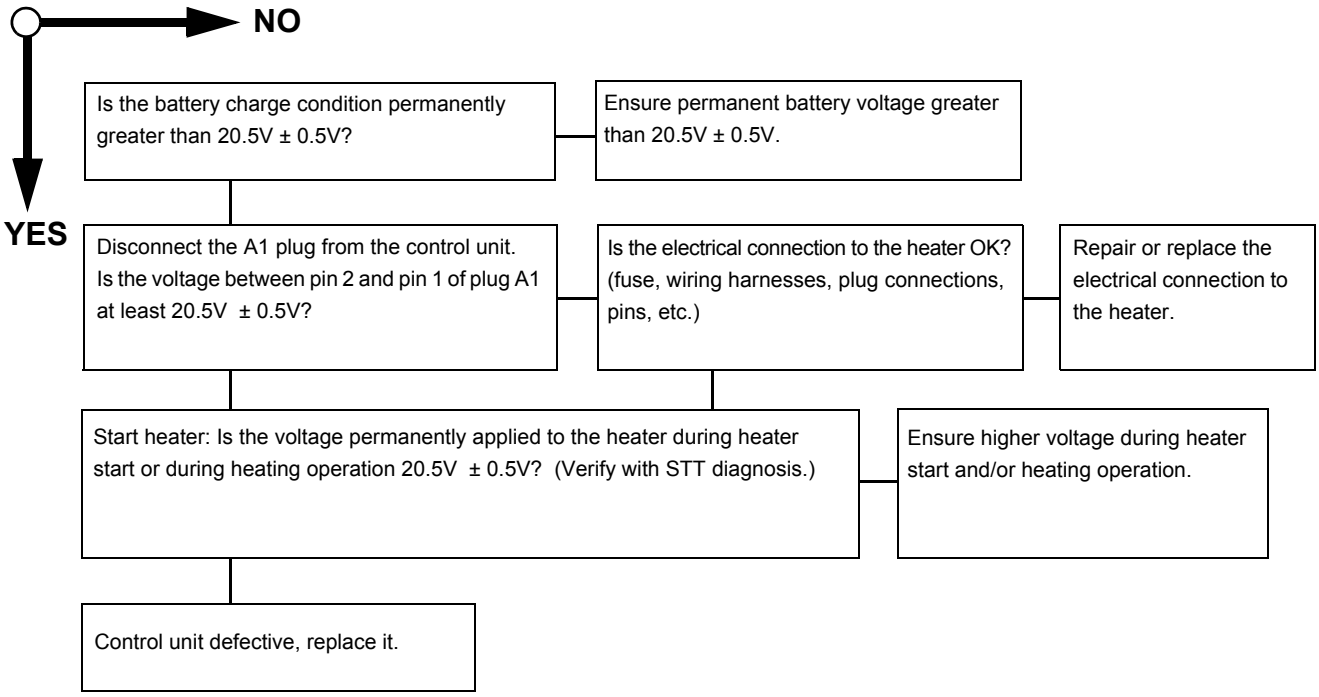
NOTE

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

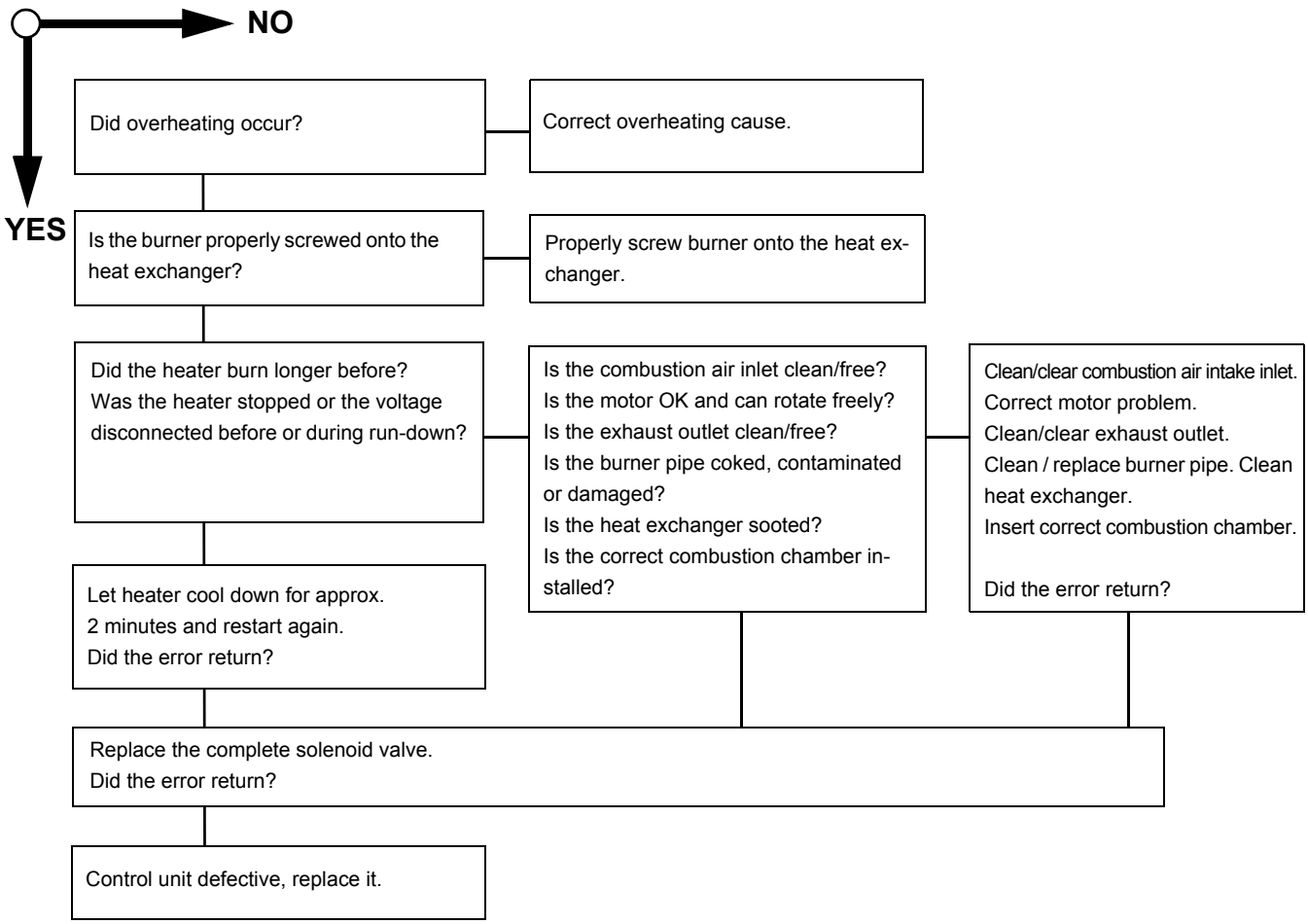

NO
YES
Are the combustion air intake opening and line and the exhaust line clean and securely mounted?
Clean and securely mount the combustion air intake opening and line and the exhaust line.
Is sufficient fresh air intake ensured and are no exhaust fumes drawn in?
Secure fresh air supply. Prevent exhaust 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 atomise?
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 pump?
Are they tightly screwed on?
Replace O-rings and filter (screen) as needed.
Is the pump pressure OK?
Adjust the pump pressure. If the prescribed pump presser does not achieve, replace the fuel pump.
Does the solenoid valve open?
Replace the complete solenoid valve.
Replace control unit.

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.



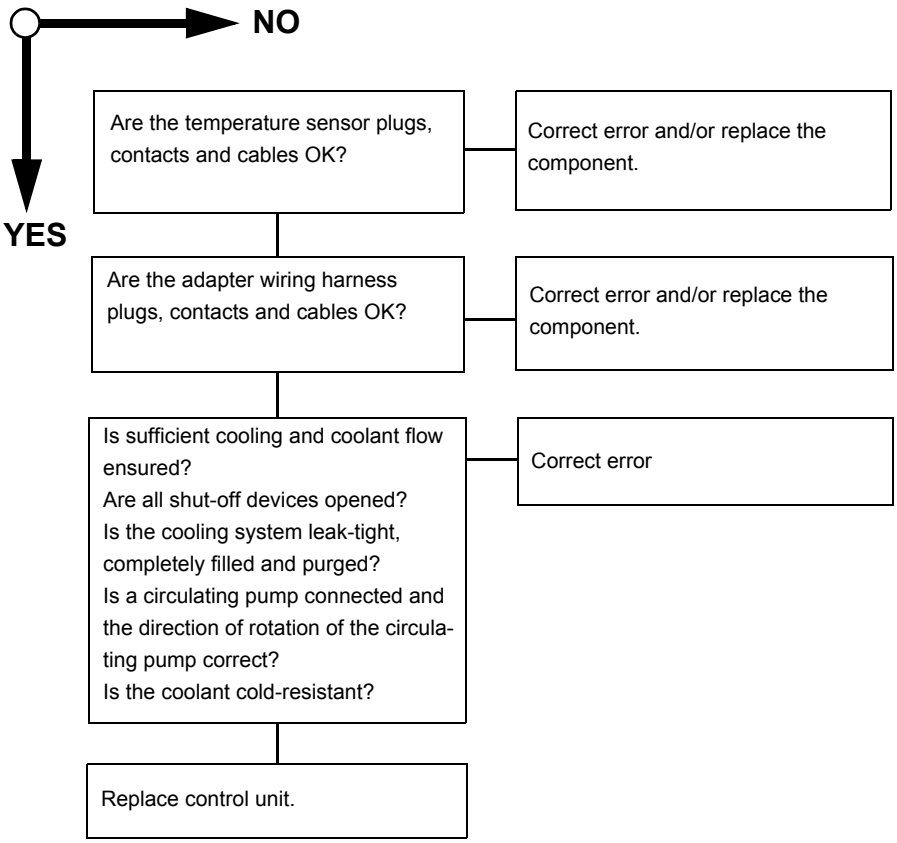
5.4.4 Error symptom "Extraneous light detected prior to ignition or during run-down"



5.4.5 Error symptom "Flame detector defective"

The flame detector cannot be replaced. It can only be tested using STT diagnosis.
In case of damage or if the target value cannot be reached, the control unit must be replaced as needed.

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



5.4.7 Error symptom "Circulating pump interruption"

The "Circulating pump interruption" error can also be triggered by dry operation of the circulating pump.

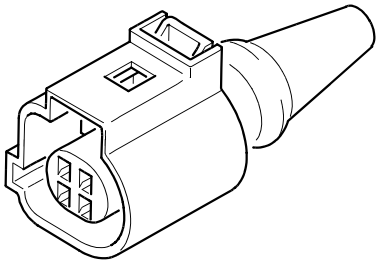
5.5 Individual component tests

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

In addition, the electrical components of the burner motor, circulating pump, electronic ignition unit, solenoid valve, nozzle block preheater operating display and flame display can be checked using the "Component Test" menu of the STT diagnosis.
The flame detector as well as the fuel pump pressure can also be checked using the "Component Test" menu of the STT diagnosis.

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

For tests using the "Component test" menu of STT diagnosis, the temperature sensor must be replaced with a test plug.



A test plug must be used for the component test with STT diagnosis.

Fig. 502

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.
If exhaust fumes exit downwards under the vehicle, exhaust gas deflection is absolutely necessary.

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 welding seam and 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).

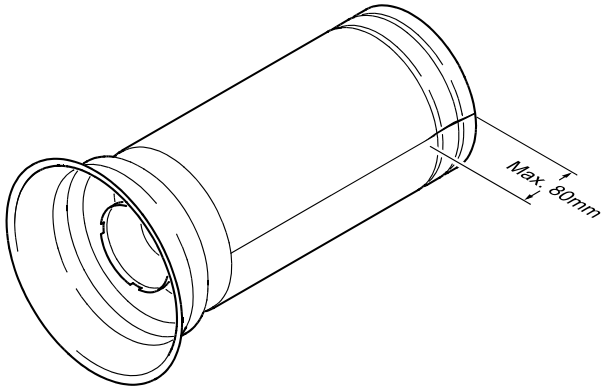


Fig. 503

5.5.4 Resistance check of the temperature sensor with integrated overheating protection

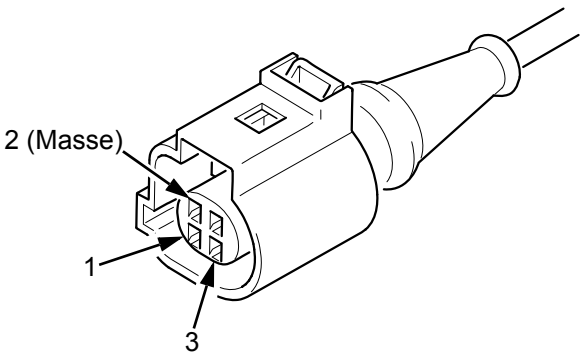
Caution!	Risk of scalds!

Prior to removing the temperature sensor, the overpressure in the cooling system must be released by opening the cooling lid. Observe the risk of injuries due to increased coolant temperature.
Possibly let heater additionally 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 water temperature sensor and the overheating protection should indicate values according to the charts.
  Preferably the resistance should be measured at an approx. consistent temperature of 20° C and approx. 100° C (immerse sensor up to the copper gasket ring into boiling water).
  Prior to reading the value, the sensor should be exposed to the temperature for approx. 20 seconds.
- Install temperature sensor (see 8.3).

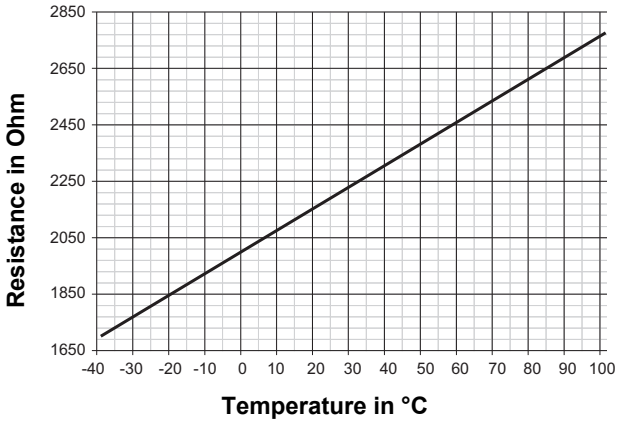


Pin 1 and 2 - overheat protection connection
Pin 2 and 3 - temperature sensor connection

Fig. 504

Resistance vs. temperature chart

Water temperature sensor (pin 2 and 3)



Overheat protection (pin 1 and 2)

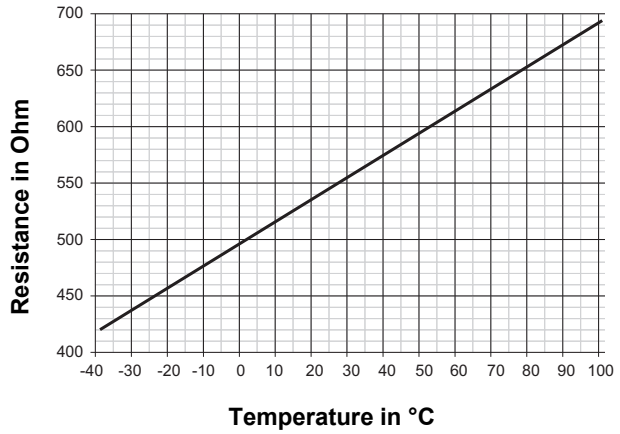


Fig. 505

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 cover plate for tight fit.
- Check circlip for proper fit.
- Install hood (see 8.4).

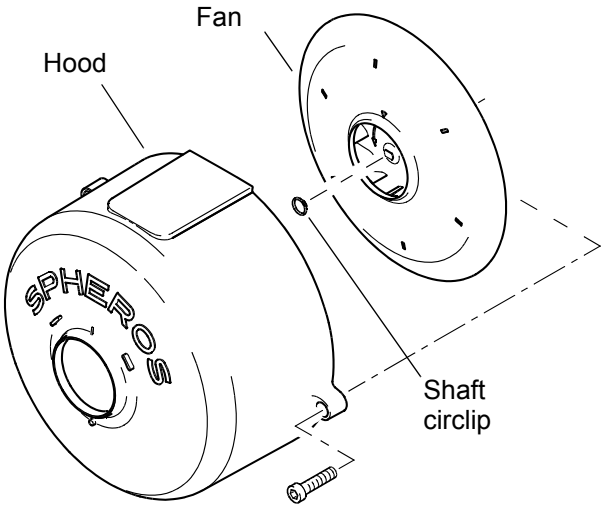


Fig. 506

5.5.6 Burner motor inspection

NOTE:
It is possible to test the burner motor using the Component Test menu of STT diagnosis.

The motor can also be checked by applying direct voltage. The electrical connection to the control unit must be disconnected first.

Inspection using STT diagnosis

- Disconnect the heater from the vehicle electrical system.
- Disconnect the temperature sensor plug and connect the test plug to the adapter wiring harness.
- Check if the motor used corresponds to the heating capacity class.

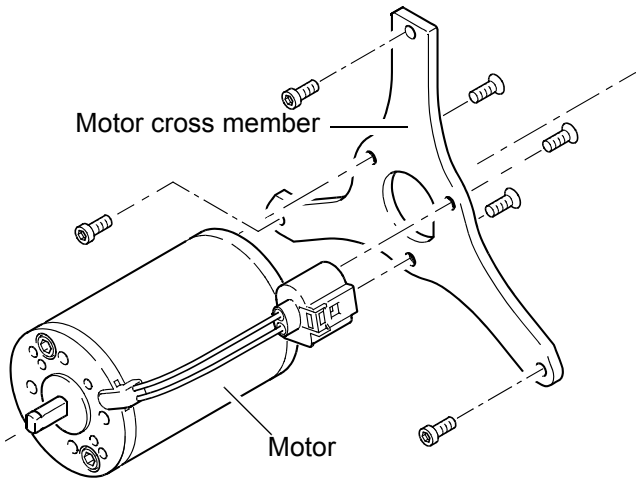


Fig. 507

- 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.
- Connect the STT diagnosis adapter to the heater and a PC via the interface in the heater wiring harness. Start STT diagnosis, establish connection to the heater and open the Component Test menu.
- Select the motor in the Component Test menu. Insert target speed and runtime. Next start the component test.

Compare the displayed actual speed with the target speed of STT diagnosis.

- After the test is completed, exit STT diagnosis as needed.
- Disconnect the heater from the vehicle electrical system.
- Disconnect the test plug and reconnect the temperature sensor plug.
- Install hood (see 8.4).

5.5.7 Electronic ignition unit inspection

NOTE:
It is possible to manually test the functionality of the electronic ignition unit, and using the Component Test menu of STT diagnosis.
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.

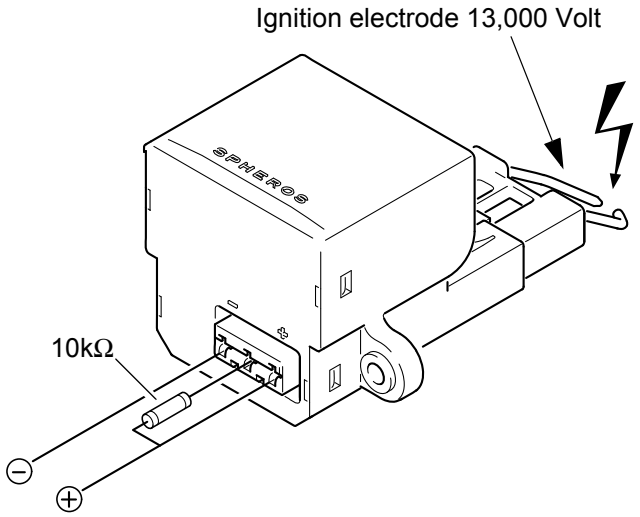


Fig. 508

Inspection using STT diagnosis
- Remove burner (see 8.2).
- Connect the test plug to the adapter wiring harness.
- Reconnect the heater to the vehicle electrical system.
- Connect the STT diagnosis adapter to the heater and a PC via the interface in the heater wiring harness. Start STT diagnosis, establish connection to the heater and open the Component Test menu.
- Select the electronic ignition unit in the Component Test menu, enter a runtime and start the component test.
- Nominal condition: Ignition sparks the ignition electrode jump over with a rate of 6Hz.
- After the test is completed, exit STT diagnosis as needed.
- Disconnect the heater from the vehicle electrical system.
- Disconnect the test plug.
- Install burner (see 8.2).

Manual functional test when disassembled
- Remove electronic ignition unit (see 8.6).
- Connect ignition electrode.
- Apply 24V direct voltage according to Fig. 508 (10kOhm on SE input).
- 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.

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

High voltage: The voltage received by the ignition electrode is >13.000 Volt.
During operation or testing the ignition electrode may not be contacted by persons or items.

Inspection

- Remove burner (see 8.2).
- Check distance of the electrode tip to the atomizer nozzle (see Fig. 509).
- Check the distance between the electrodes (see Fig. 509).

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.

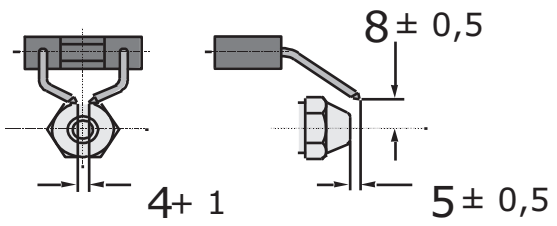


Fig. 509

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. 510) must be cleaned.
The flame detector is permanently integrated into the control unit and cannot be replaced.
Functionality is verified using STT diagnosis.
In case of damage or if the target value cannot be reached, the control unit must be replaced as needed.

Inspection

- Remove burner (see 8.2).
- Connect the test plug to the adapter wiring harness.
- Connect the heater to the vehicle electrical system.
- Connect the STT diagnosis adapter to the heater and a PC via the interface in the heater wiring harness. Start STT diagnosis and establish the connection to the heater.
- Cover the glass body of the flame detector.
- Check the flame detector voltage displayed on a PC by STT diagnosis (target value: U = 4.60V...4.74V).
- Remove the cover from the glass body of the flame detector and illuminate from close distance using a bright lamp.
- Check the flame detector voltage displayed on a PC by STT diagnosis (target value: U = 0.60V...1.50V).
- After the test is completed, exit STT diagnosis as needed.
- Disconnect the heater from the vehicle electrical system.
- Disconnect the test plug as needed.
- Install burner (see 8.2).

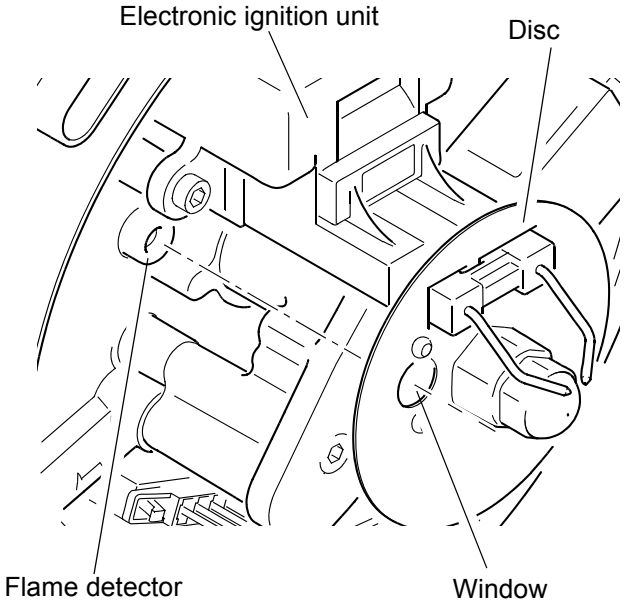


Fig. 510

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.

According to the manufacturer's specifications the fuel pump and fuel hoses must be replaced after 5 years.

NOTE:
If bio diesel or FAME is used, the fuel pump and fuel lines must be replaced according to the latest technical information / notification.

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

The ignition electrode must be removed during the pump pressure check.

NOTE:
The fuel pump pressure can be checked while the burner is disassembled, using the Component Test menu of STT diagnosis.

A pressure test gauge with a display range from 0 to 15 bar as well as a bleeding feature is required (Fig. 512). 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 fuel pump and atomizer nozzle used correspond to the heating capacity class?
- Is the fuel temperature 15...25°C?
- Are available check valves in the fuel (pre-)flow and return line opened?
- Was the fuel filter in the fuel (pre-)flow line replaced?
- Are the filters (screens) in the pump inlet clean?
- Is the fuel delivered without bubbles?

Attach a transparent hose for testing.

Inspection using STT diagnosis
- Remove burner (see 8.2).
- Connect the test plug to the adapter wiring harness.
- Connect the heater to the vehicle electrical system.
- Connect the STT diagnosis adapter to the heater and a PC via the interface in the heater wiring harness. Start STT diagnosis, establish connection to the heater and open the Component Test menu.
- Select and start the pump pressure test in the Component Test menu.
- Check the information and follow the instructions provided by STT diagnosis.
- The motor is started using the speed programmed in the control unit.
- 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 Table 503.

If the specified pressure cannot be reached, it can be readjusted. For that rotate the adjusting screw (see Fig. 511) max. one revolution. If the prescribed pressure despite readjustment not be achieved or occur leaks, the fuel pump must be replaced.

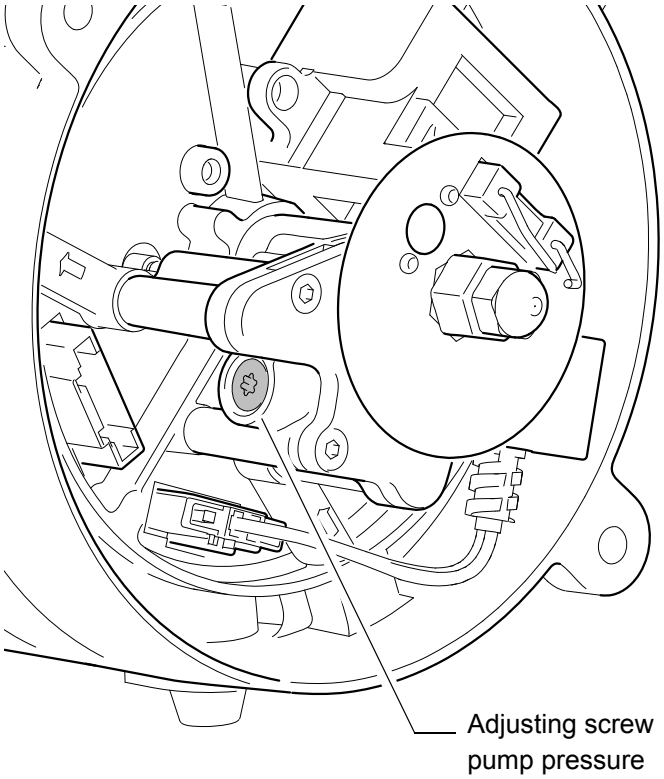
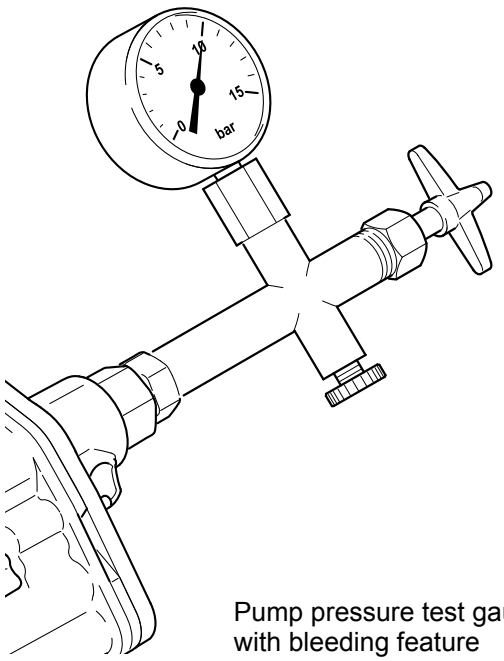


Fig. 511

- Follow the instructions provided by STT diagnosis.
- After the test is completed, exit STT diagnosis as needed.
- Disconnect the heater from the vehicle electrical system.
- Disconnect the test plug.
- Install burner (see 8.2).

Table 503 Fuel pump pressures

Heater	CO_2 [Vol.-%]	without fuel delivery by nozzle [bar]	with fuel delivery by nozzle [bar]
S160	9.5 + 1.5	10.1 ± 0.3	10.0 ± 0.4
S230	9.5 + 1.5	10.2 ± 0.3	9.8 ± 0.4
S300	9.5 + 1.5	10.6 ± 0.3	10 ± 0.4
S350	9.5 + 1.5	10.9 ± 0.3	10.4 ± 0.4
S400	9.5 + 1.5	9.5 ± 0.3	9.1 ± 0.4



Pump pressure test gauge with bleeding feature

Fig. 512

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 run-down. Fuel drips from the atomizer nozzle.
A not closing solenoid valve may cause heater deactivation during run-down with heater interlock activation.

It is possible to manually test the electrical functionality of the solenoid valve, and using the Component Test menu of STT diagnosis.

Inspection using STT diagnosis

- Remove burner (see 8.2).
- Connect the test plug to the adapter wiring harness.
- Connect the heater to the vehicle electrical system.
- Connect the STT diagnosis adapter to the heater and a PC via the interface in the heater wiring harness. Start STT diagnosis, establish connection to the heater and open the Component Test menu.
- Select and start the solenoid valve in the Component Test menu.
- The solenoid valve must audibly open.
- After the test is completed, exit STT diagnosis as needed.
- Disconnect the heater from the vehicle electrical system.
- Disconnect the test plug.
- Install burner (see 8.2).

Manual inspection:

- Remove burner (see 8.2).
- Disconnect the solenoid valve plug from the control unit.
- Check the electrical functionality by applying direct voltage:
  - Opening voltage: starting at 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.

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

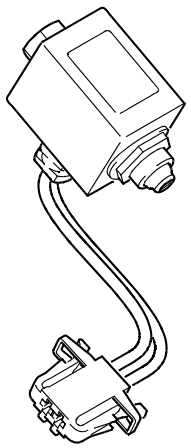


Fig. 513 Solenoid valve

5.5.12 Nozzle block preheater inspection

Caution!	Risk of burns!

The heating element of the nozzle block preheater can heat up during inspection.
Do not pull heating element out of the nozzle holder during 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 temperature and the vehicle electrical system voltage.
The power consumption at 24 Volt amounts to approx. 130 Watt.

Inspection using STT diagnosis

- Remove burner (see 8.2).
- Connect the test plug to the adapter wiring harness.
- Connect the heater to the vehicle electrical system.
- Connect the STT diagnosis adapter to the heater and a PC via the interface in the heater wiring harness. Start STT diagnosis, establish connection to the heater and open the Component Test menu.
- Select the optional nozzle block preheater in the Component Test menu, select a runtime and start the component test.

Nominal condition: The heating element warms up.

- After the test is completed, exit STT diagnosis as needed.
- Disconnect the heater from the vehicle electrical system.
- Disconnect the test plug.
- Install burner (see 8.2).

Manual inspection

- Remove burner (see 8.2).
- Disconnect the nozzle block preheater plug from the control unit.
- If necessary, remove the nozzle block preheater.
- Check the electrical resistance:

Heating element between pin 1 and 2:

max. 3.9...4.9Ω at 20°C.

- If necessary, install the nozzle block preheater.
- Connect the nozzle block preheater plug to the control unit.

- Install burner (see 8.2).

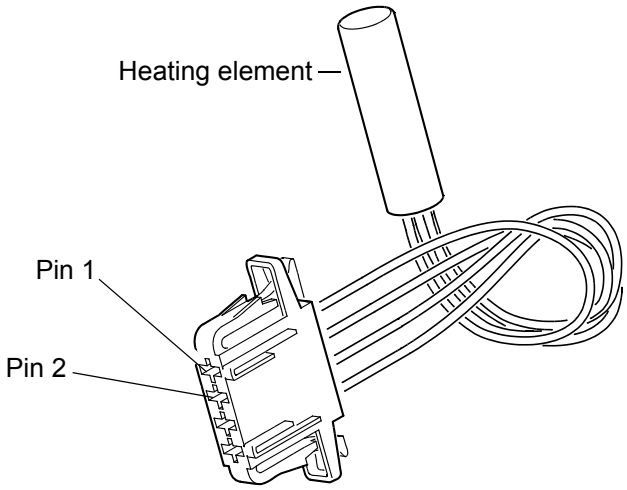


Fig. 514

5.5.13 Circulating pump inspection

ATTENTION:

The fuse of the circulating pump may never be pulled, while the pump is running.

Inspection using STT diagnosis

- Disconnect the heater from the vehicle electrical system.

- Disconnect the temperature sensor plug and connect the test plug to the adapter wiring harness.

- Check the electrical connections as well as the cooling system for leak-tightness.

- Connect the heater to the vehicle electrical system.

- Connect the STT diagnosis adapter to the heater and a PC via the interface in the heater wiring harness. Start STT diagnosis, establish connection to the heater and open the Component Test menu.

- Select and start the circulating pump in the Component Test menu and start the component test.

- After the test is completed, exit STT diagnosis as needed.

- Disconnect the heater from the vehicle electrical system.
  Disconnect the test plug and reconnect the temperature sensor plug.

- Connect the heater to the vehicle electrical system.

6 Schematic diagrams

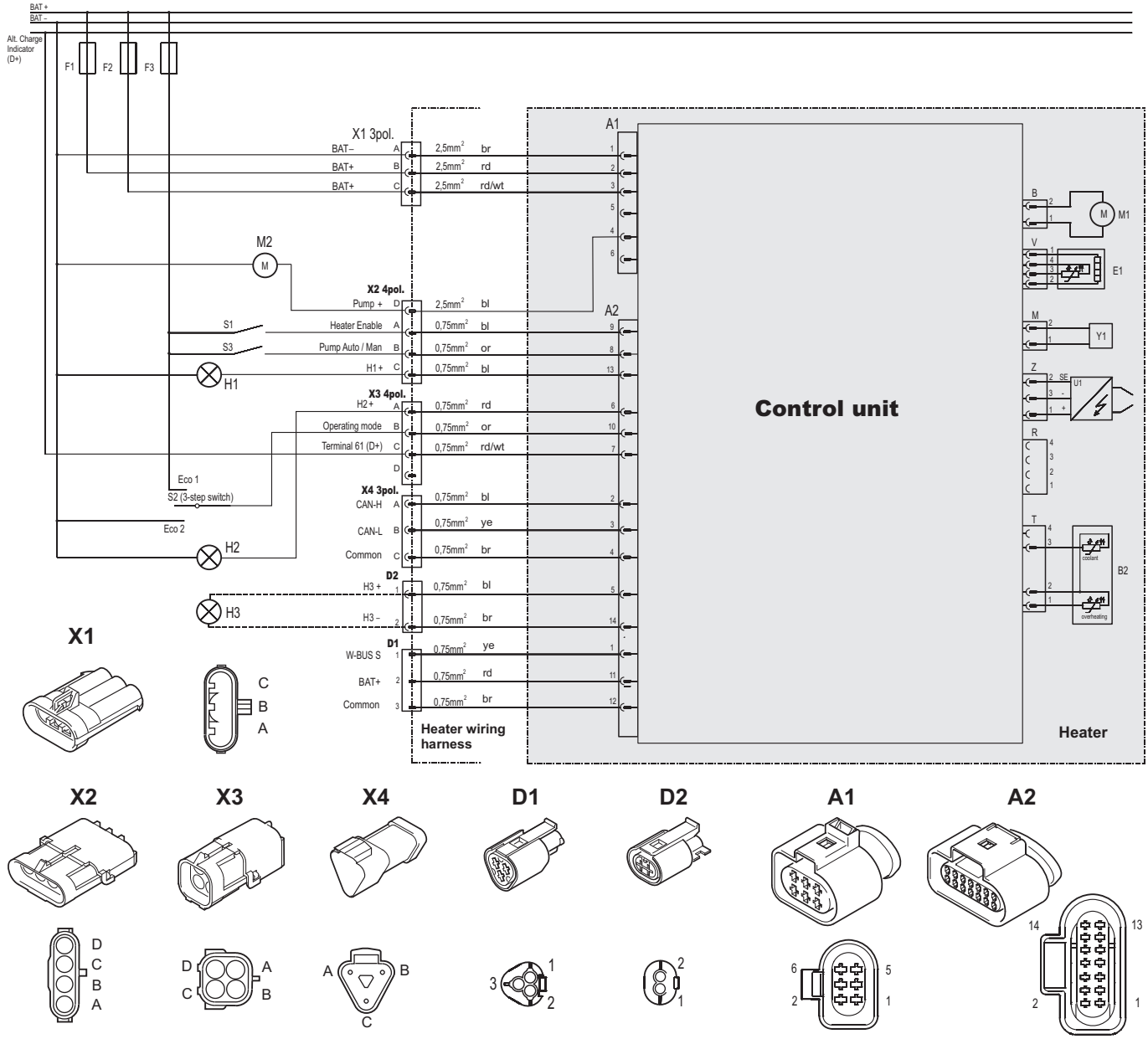
6.1 General

The following figures represent customer-dependent heater connection options to the vehicle electrical system. The heater wiring harness cables as well as the cables of the vehicle electrical system are shown.

ATTENTION:

In case of vehicle cable lengths up to 7.5 m the cable cross-sections must be at least of the same size as the respectively corresponding cable of the heater wiring harness.

In case of vehicle cable lengths between 7.5 m and 15 m the cable cross-sections in the vehicle must be larger dimensioned than the respectively corresponding cable of the heater wiring harness. The cable cross-sections indicated in the table must be applied.



Item	Description
H1	Operation Indicator Light (Max. 5 W)
H2	Flame Indicator Light (Max. 5 W)
H3	Optional Diagnostic Light (Max. 5 W)
E1	Fuel Nozzle Preheater
M1	Combustion Air Fan Motor
M2	Circulation Pump
B2	Temperature Sensor and Limiter
Y1	Fuel Solenoid Valve
U1	Electronic Ignition Unit
S1	Main Switch - (Heater Enable On/ Off)
S2	Operation Mode Switch - (Normal/ Economy)
S3	Pump Control Switch - (Automatic/ Manual)
F1	Fuse 25A - SAE J1284
F2	Fuse 25A - SAE J1284
F3	Fuse 5A - SAE J1284

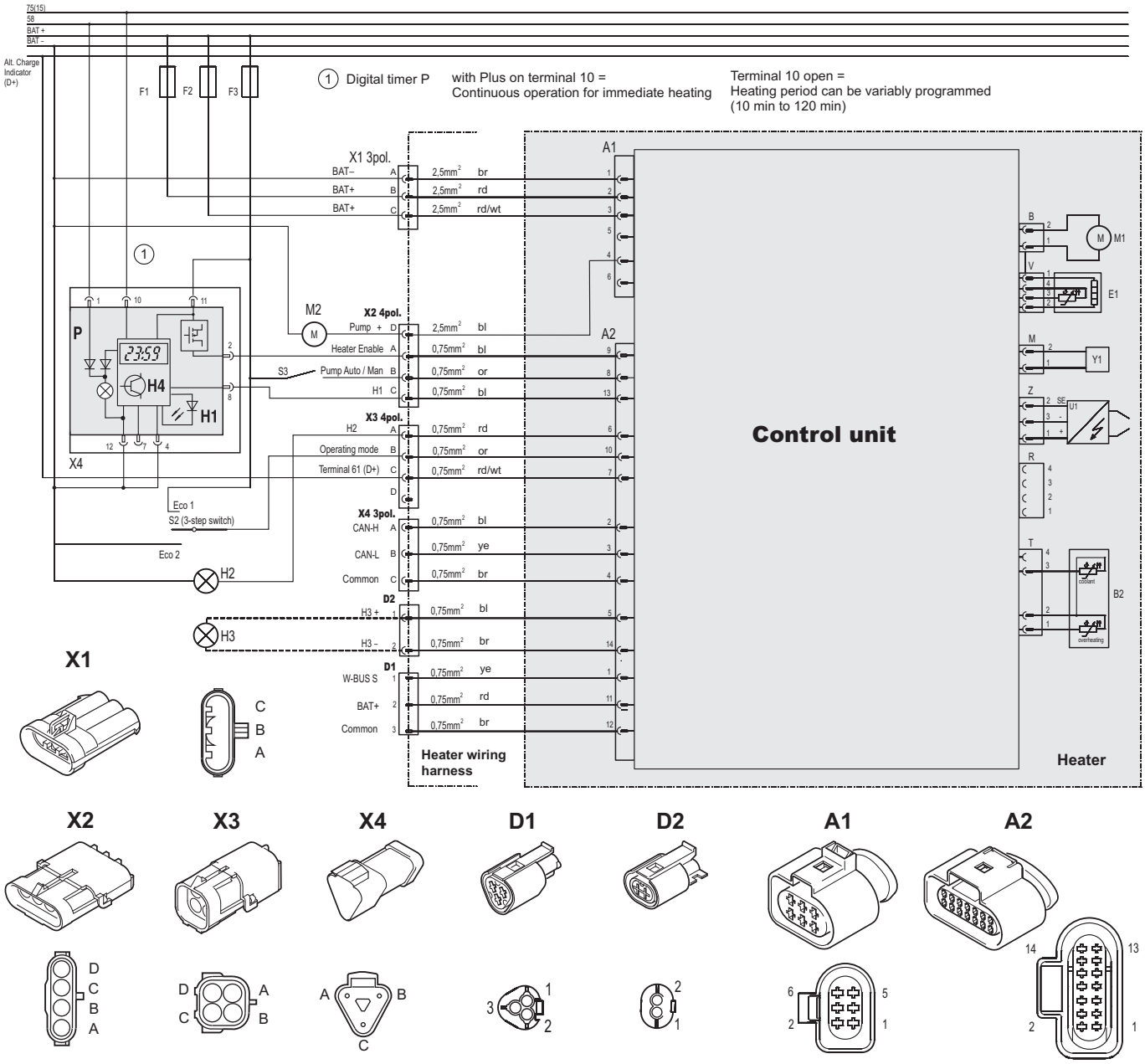
Legend

Cable cross-section in heater wiring harness	Cable cross section for cable lengths in vehicle	
	< 7.5 m (< 24ft)	7.5 - 15m (24 - 50ft.)
0.75 mm² 18 ga	0.75 mm²	1.5 mm² 14 ga
1.0 mm² 16 ga	1.0 mm²	1.5 mm² 14 ga
1.5 mm² 14 ga	1.5 mm²	2.5 mm² 12 ga
2.5 mm² 12 ga	2.5 mm²	4.0 mm² 10 ga
4.0 mm² 10 ga	4.0 mm²	6.0 mm² 8 ga

Note:
For cable lengths below 7.5 m in the vehicle, at least the same cable cross-sections as in the heater wiring harness must be used. For cables lengths between 7.5 m and 15 m in the vehicle, the cable cross sections must be enlarged according to the table.

Line colours	
bl	blue
br	brown
ye	yellow
ge	green
gr	grey
or	orange
rd	red
bl	black
vi	violet
wt	white
rd/wt	red/white

Fig. 601 Standard system connection to wiring harness 11115706_



Item	Description
H1	Operation Indicator Light (Max. 5 W)
H2	Flame Indicator Light (Max. 5 W)
H3	Optional Diagnostic Light (Max. 5 W)
E1	Fuel Nozzle Preheater
M1	Combustion Air Fan Motor
M2	Circulation Pump
B2	Temperature Sensor and Limiter
Y1	Fuel Solenoid Valve
U1	Electronic Ignition Unit
S1	Main Switch - (Heater Enable On/ Off)
S2	Operation Mode Switch - (Normal/ Economy)
S3	Pump Control Switch - (Automatic/ Manual)
F1	Fuse 25A - SAE J1284
F2	Fuse 25A - SAE J1284
F3	Fuse 5A - SAE J1284

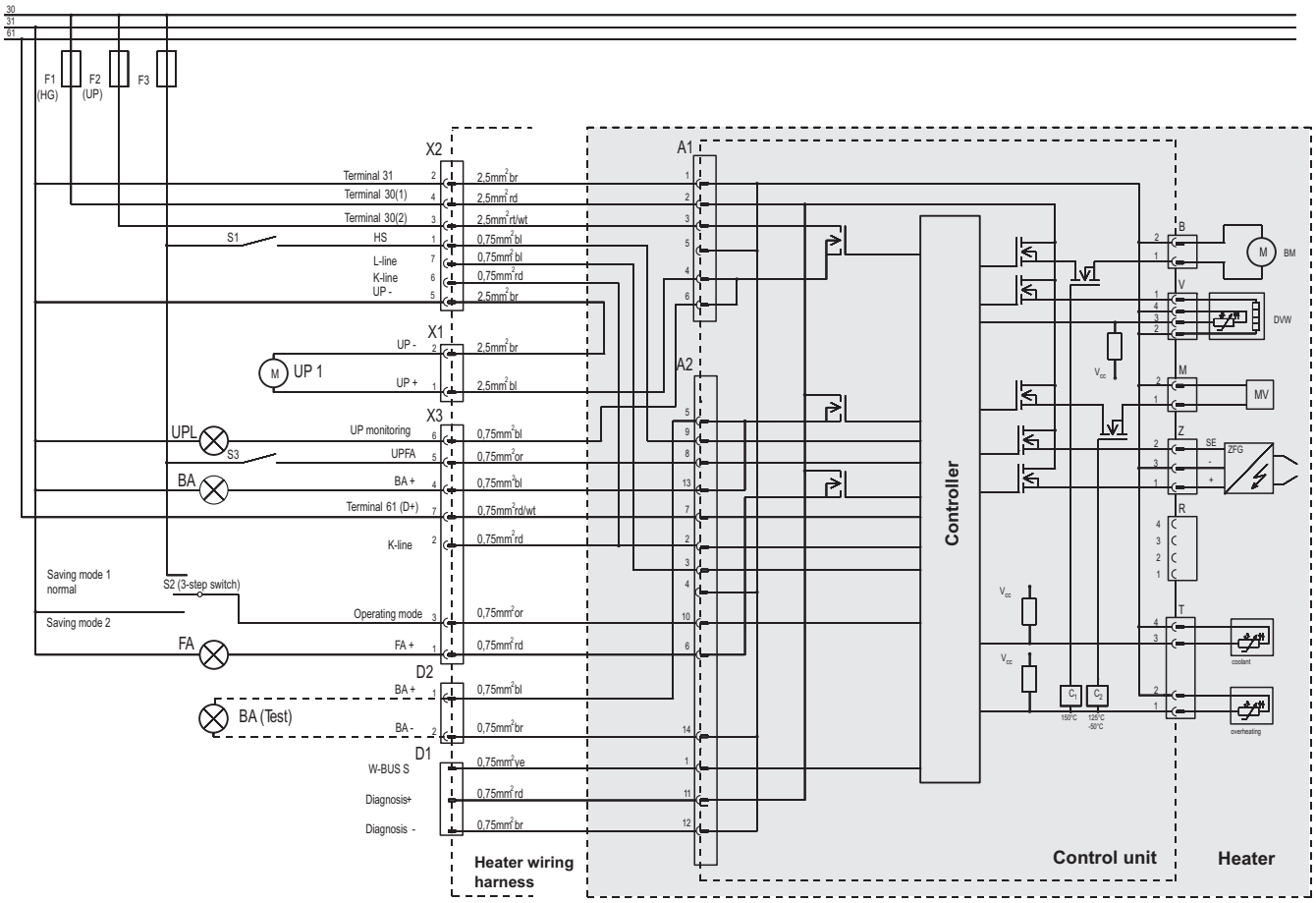
Legend

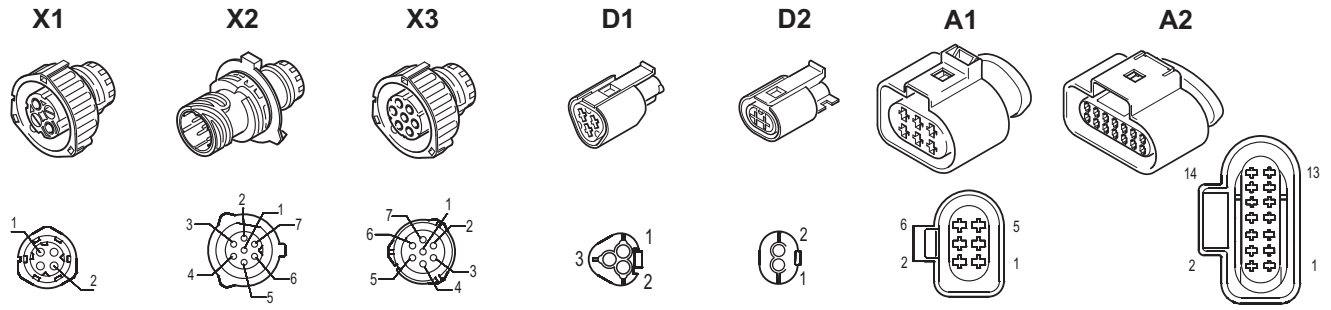
Cable cross-section in heater wiring harness	Cable cross section for cable lengths in vehicle	
	< 7.5 m (< 24ft)	7.5 - 15m (24 - 50ft.)
0.75 mm² 18 ga	0.75 mm²	1.5 mm² 14 ga
1.0 mm² 16 ga	1.0 mm²	1.5 mm² 14 ga
1.5 mm² 14 ga	1.5 mm²	2.5 mm² 12 ga
2.5 mm² 12 ga	2.5 mm²	4.0 mm² 10 ga
4.0 mm² 10 ga	4.0 mm²	6.0 mm² 8 ga

Note:
For cable lengths below 7.5 m in the vehicle, at least the same cable cross-sections as in the heater wiring harness must be used. For cables lengths between 7.5 m and 15 m in the vehicle, the cable cross sections must be enlarged according to the table.

Line colours	
bl	blue
br	brown
ye	yellow
ge	green
gr	grey
or	orange
rd	red
bl	black
vi	violet
wt	white
rd/wt	red/white

Fig. 602 Standard system connection with digital timer to wiring harness 11115706_





Item	Description
BA	Operating display max. 5W
BM	Combustion air motor
DVW	Nozzle block preheater
F1	Vehicle blade-type fuse 25 A according to DIN 72581 part 3
F2	Vehicle blade-type fuse 25 A according to DIN 72581 part 3
F3	Vehicle blade-type fuse 5A according to DIN 72581 part 3
FA	Flame display max. 5W
HS	Main switch
MV	Solenoid valve
S1	Main switch - heater On/Off
S2	Switch - operating mode - saving mode
S3	Switch - UP On/Off (without heating function)
S4	Switch UP 2 On/Off
UP	Circulating pump
UPFA	External circulating pump actuation
UPL	Optional circulating pump display for testing, max. 5W

Legend

Item	Description
BA (Test)	Optionally connectible lamp for diagnosis purposes, max. 5W
ZFG	Electronic ignition unit

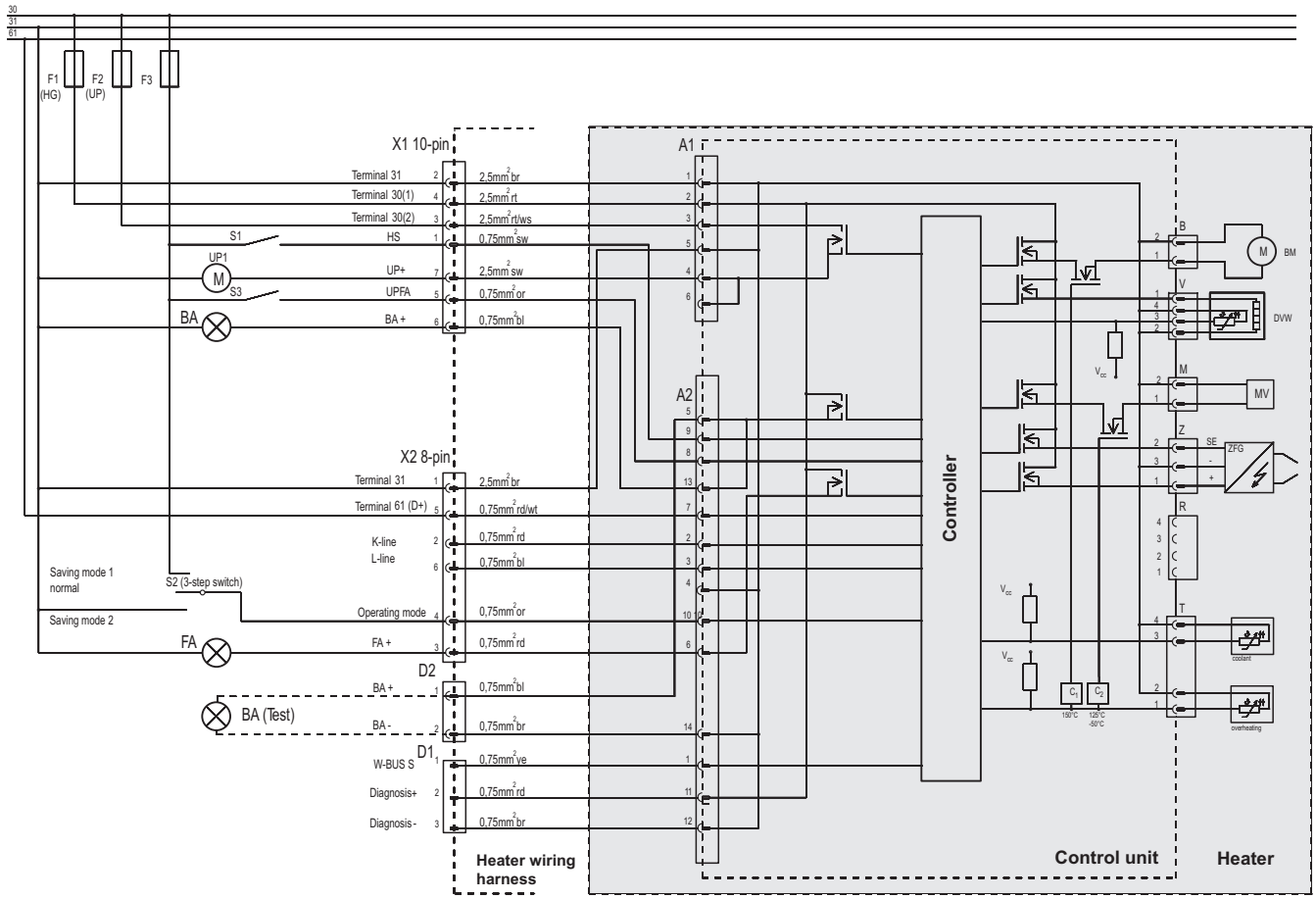
Legend (cont.)

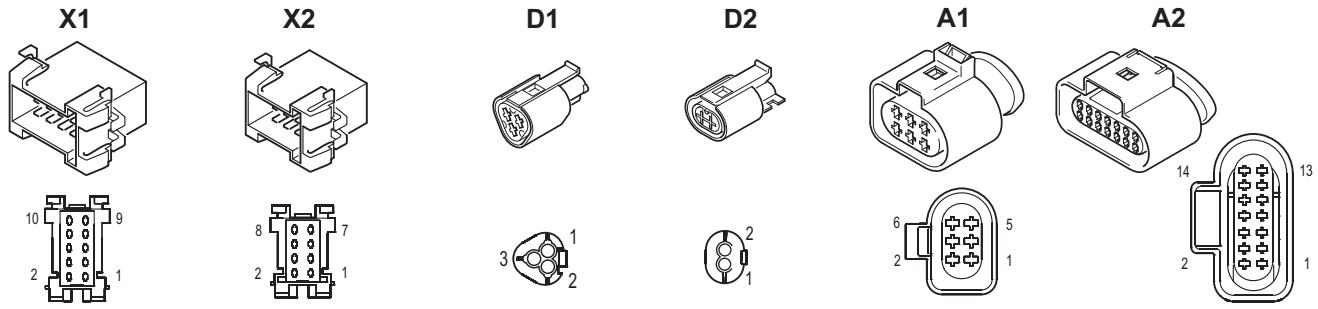
Cable cross-section in heater wiring harness	Cable cross section for cable lengths in vehicle	
	< 7.5 m	7.5 - 15m
0.75 mm^2	0.75 mm^2	1.5 mm^2
1.0 mm^2	1.0 mm^2	1.5 mm^2
1.5 mm^2	1.5 mm^2	2.5 mm^2
2.5 mm^2	2.5 mm^2	4.0 mm^2
4.0 mm^2	4.0 mm^2	6.0 mm^2

Note:
For cable lengths below 7.5 m in the vehicle, at least the same cable cross-sections as in the heater wiring harness must be used. For cables lengths between 7.5 m and 15 m in the vehicle, the cable cross sections must be enlarged according to the table.

Line colours	
bl	blue
br	brown
ye	yellow
ge	green
gr	grey
or	orange
rd	red
bl	black
vi	violet
wt	white
rd/wt	red/white

Fig. 603 EvoBus system connection to wiring harness 11111288_, watertight





Item	Description
BA	Operating display max. 5W
BM	Combustion air motor
DVW	Nozzle block preheater
F1	Vehicle blade-type fuse 25 A according to DIN 72581 part 3
F2	Vehicle blade-type fuse 25 A according to DIN 72581 part 3
F3	Vehicle blade-type fuse 5A according to DIN 72581 part 3
FA	Flame display max. 5W
HS	Main switch
MV	Solenoid valve
S1	Main switch - heater On/Off
S2	Switch - operating mode - saving mode
S3	Switch - UP On/Off (without heating function)
S4	Switch UP 2 On/Off
UP	Circulating pump
UPFA	External circulating pump actuation
UPL	Optional circulating pump display for testing, max. 5W

Legend

Item	Description
BA (Test)	Optionally connectible lamp for diagnosis purposes, max. 5W
ZFG	Electronic ignition unit

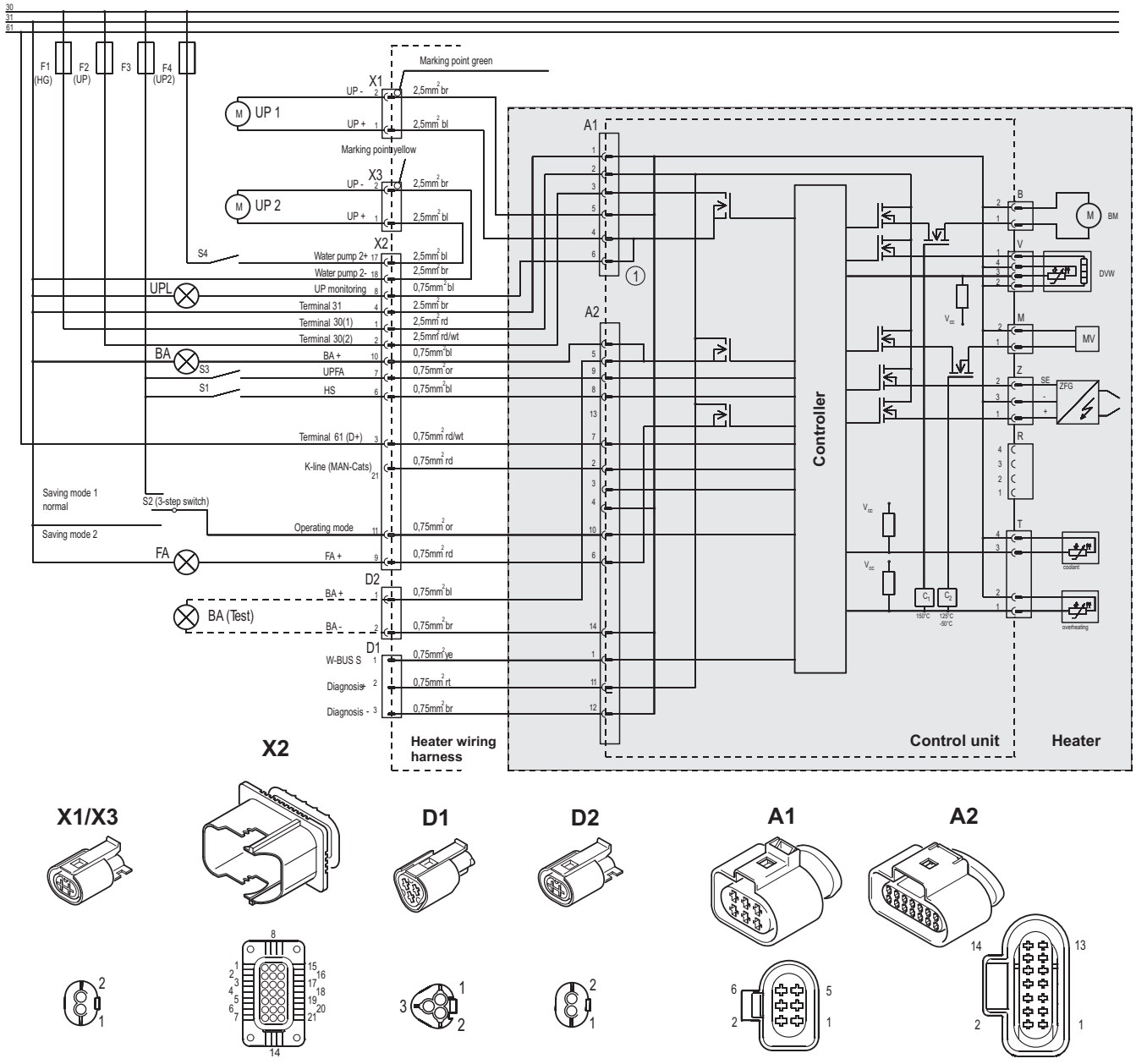
Legend (cont.)

Cable cross-section in heater wiring harness	Cable cross section for cable lengths in vehicle	
	< 7.5 m	7.5 - 15m
0.75 mm²	0.75 mm²	1.5 mm²
1.0 mm²	1.0 mm²	1.5 mm²
1.5 mm²	1.5 mm²	2.5 mm²
2.5 mm²	2.5 mm²	4.0 mm²
4.0 mm²	4.0 mm²	6.0 mm²

Note:
For cable lengths below 7.5 m in the vehicle, at least the same cable cross-sections as in the heater wiring harness must be used. For cables lengths between 7.5 m and 15 m in the vehicle, the cable cross sections must be enlarged according to the table.

Line colours	
bl	blue
br	brown
ye	yellow
ge	green
gr	grey
or	orange
rd	red
bl	black
vi	violet
wt	white
rd/wt	red/white

Fig. 604 Standard system connection to wiring harness 11111289_



Item	Description
BA	Operating display max. 5W
BM	Combustion air motor
DVW	Nozzle block preheater
F1	Vehicle blade-type fuse 25 A according to DIN 72581 part 3
F2	Vehicle blade-type fuse 25 A according to DIN 72581 part 3
F3	Vehicle blade-type fuse 5A according to DIN 72581 part 3
FA	Flame display max. 5W
HS	Main switch
MV	Solenoid valve
S1	Main switch - heater On/Off
S2	Switch - operating mode - saving mode
S3	Switch - UP On/Off (without heating function)
S4	Switch UP 2 On/Off
UP	Circulating pump
UPFA	External circulating pump actuation
UPL	Optional circulating pump display for testing, max. 5W

Legend

Item	Description
BA (Test)	Optionally connectible lamp for diagnosis purposes, max. 5W
ZFG	Electronic ignition unit

Legend (cont.)

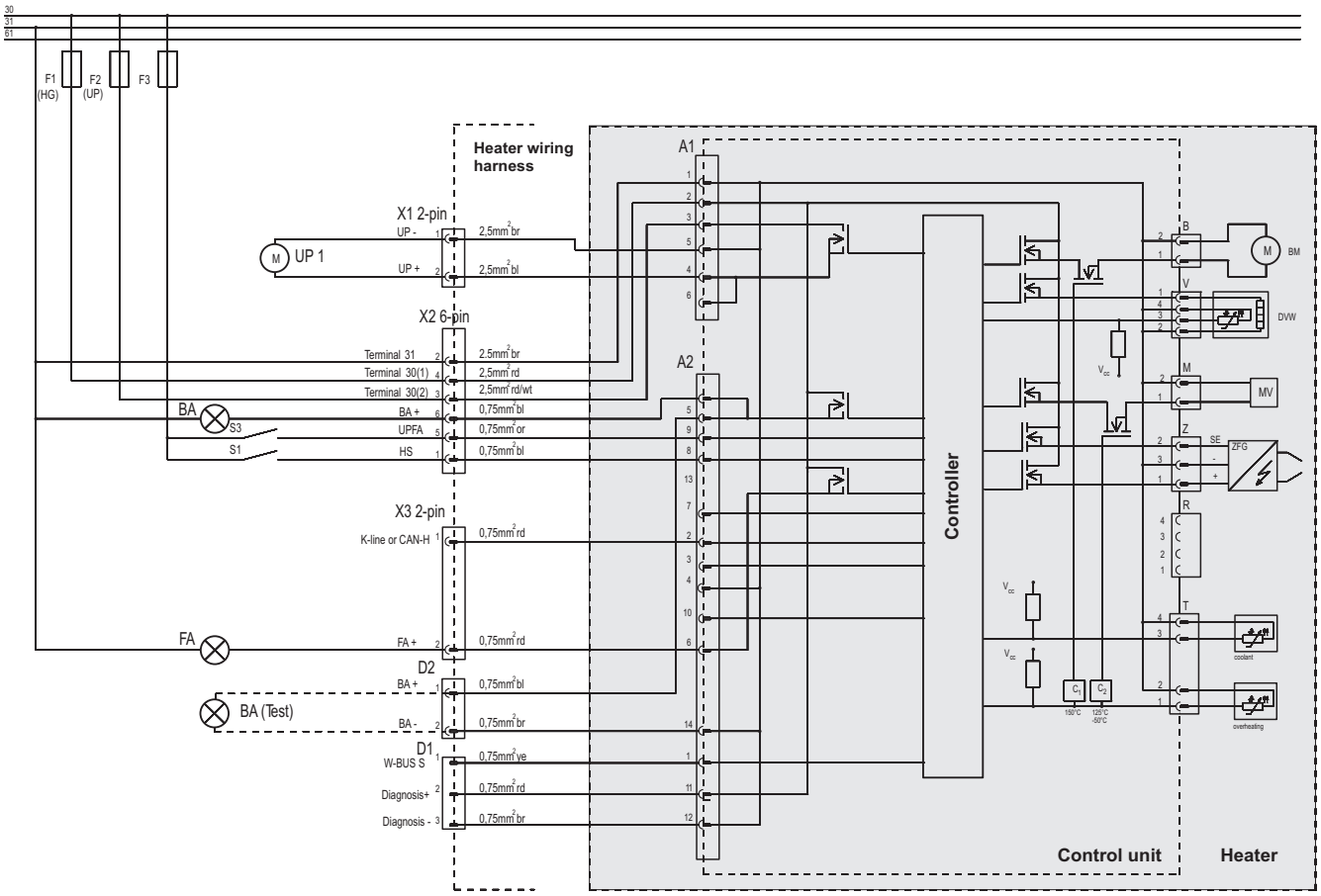
Cable cross-section in heater wiring harness	Cable cross section for cable lengths in vehicle	
	< 7.5 m	7.5 - 15m
0.75 mm²	0.75 mm²	1.5 mm²
1.0 mm²	1.0 mm²	1.5 mm²
1.5 mm²	1.5 mm²	2.5 mm²
2.5 mm²	2.5 mm²	4.0 mm²
4.0 mm²	4.0 mm²	6.0 mm²

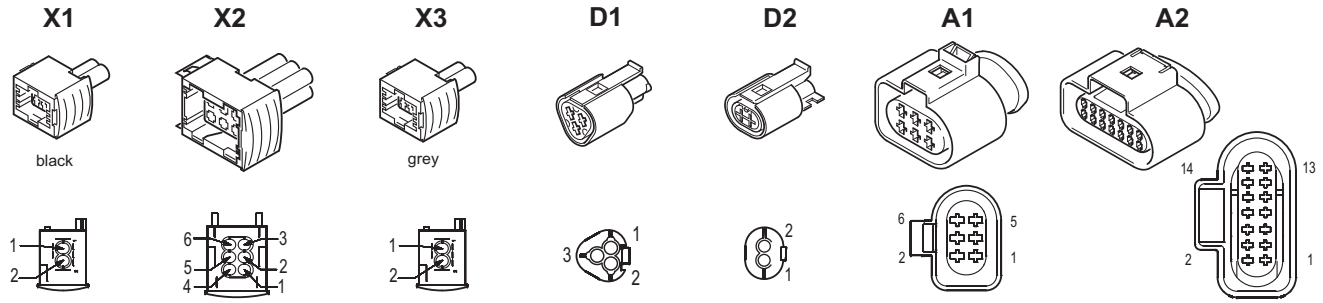
Note:

For cable lengths below 7.5 m in the vehicle, at least the same cable cross-sections as in the heater wiring harness must be used. For cables lengths between 7.5 m and 15 m in the vehicle, the cable cross sections must be enlarged according to the table.

Line colours	
bl	blue
br	brown
ye	yellow
ge	green
gr	grey
or	orange
rd	red
bl	black
vi	violet
wt	white
rd/wt	red/white

Fig. 605 MAN system connection to wiring harness 11111290_





Item	Description
BA	Operating display max. 5W
BM	Combustion air motor
DVW	Nozzle block preheater
F1	Vehicle blade-type fuse 25 A according to DIN 72581 part 3
F2	Vehicle blade-type fuse 25 A according to DIN 72581 part 3
F3	Vehicle blade-type fuse 5A according to DIN 72581 part 3
FA	Flame display max. 5W
HS	Main switch
MV	Solenoid valve
S1	Main switch - heater On/Off
S2	Switch - operating mode - saving mode
S3	Switch - UP On/Off (without heating function)
S4	Switch UP 2 On/Off
UP	Circulating pump
UPFA	External circulating pump actuation
UPL	Optional circulating pump display for testing, max. 5W

Legend

Item	Description
BA (Test)	Optionally connectible lamp for diagnosis purposes, max. 5W
ZFG	Electronic ignition unit

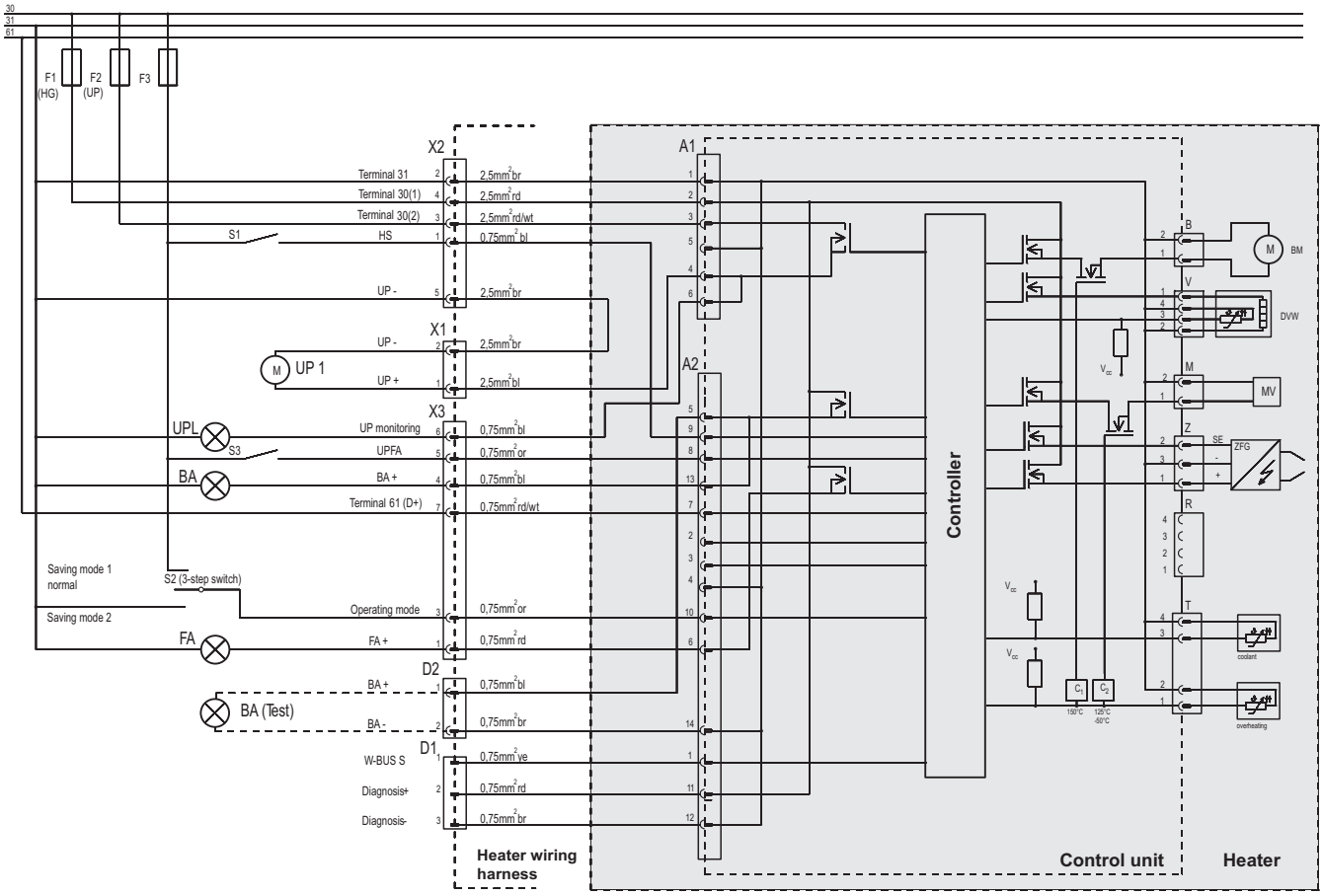
Legend (cont.)

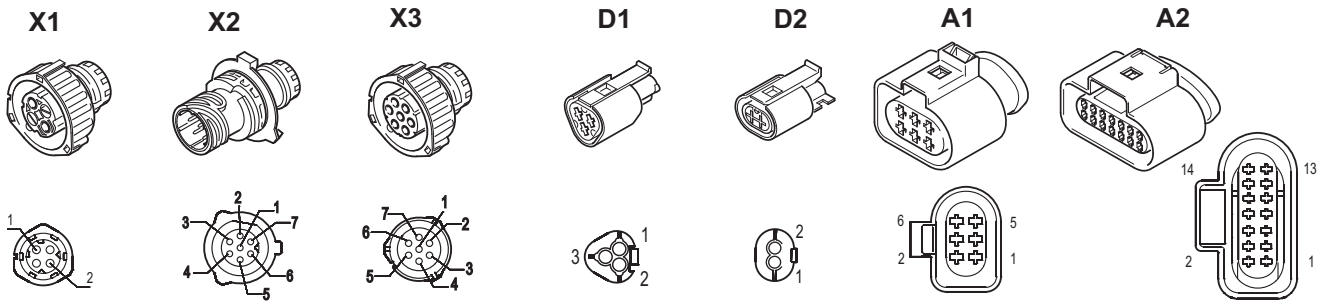
Cable cross-section in heater wiring harness	Cable cross section for cable lengths in vehicle	
	< 7.5 m	7.5 - 15m
0.75 mm²	0.75 mm²	1.5 mm²
1.0 mm²	1.0 mm²	1.5 mm²
1.5 mm²	1.5 mm²	2.5 mm²
2.5 mm²	2.5 mm²	4.0 mm²
4.0 mm²	4.0 mm²	6.0 mm²

Note:
For cable lengths below 7.5 m in the vehicle, at least the same cable cross-sections as in the heater wiring harness must be used. For cables lengths between 7.5 m and 15 m in the vehicle, the cable cross sections must be enlarged according to the table.

Line colours	
bl	blue
br	brown
ye	yellow
ge	green
gr	grey
or	orange
rd	red
bl	black
vi	violet
wt	white
rd/wt	red/white

Fig. 606 IRISBUS system connection to wiring harness 11111292_





Item	Description
BA	Operating display max. 5W
BM	Combustion air motor
DVW	Nozzle block preheater
F1	Vehicle blade-type fuse 25 A according to DIN 72581 part 3
F2	Vehicle blade-type fuse 25 A according to DIN 72581 part 3
F3	Vehicle blade-type fuse 5A according to DIN 72581 part 3
FA	Flame display max. 5W
HS	Main switch
MV	Solenoid valve
S1	Main switch - heater On/Off
S2	Switch - operating mode - saving mode
S3	Switch - UP On/Off (without heating function)
S4	Switch UP 2 On/Off
UP	Circulating pump
UPFA	External circulating pump actuation
UPL	Optional circulating pump display for testing, max. 5W

Legend

Item	Description
BA (Test)	Optionally connectible lamp for diagnosis purposes, max. 5W
ZFG	Electronic ignition unit

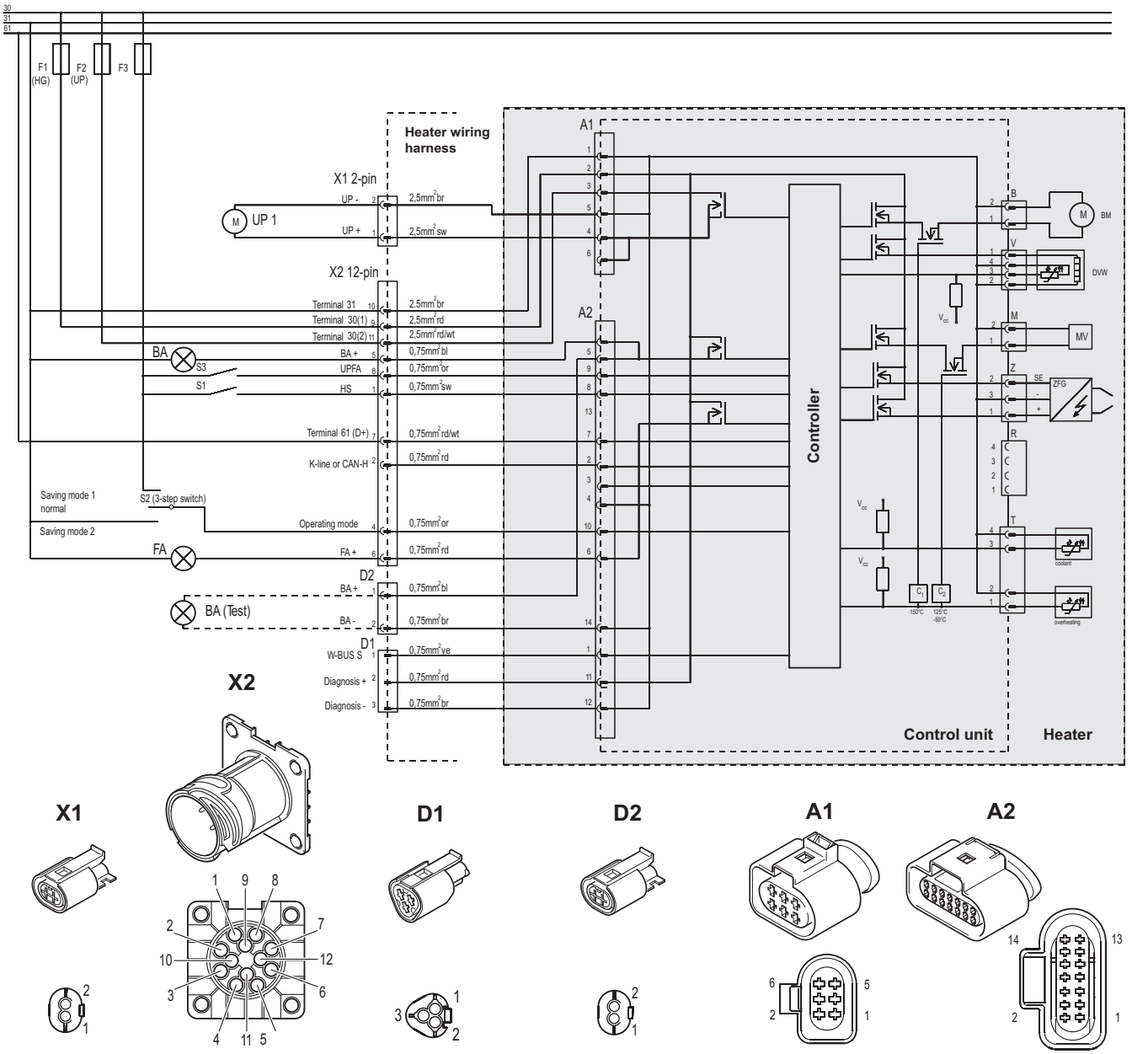
Legend (cont.)

Cable cross-section in heater wiring harness	Cable cross section for cable lengths in vehicle	
	< 7.5 m	7.5 - 15m
0.75 mm²	0.75 mm²	1.5 mm²
1.0 mm²	1.0 mm²	1.5 mm²
1.5 mm²	1.5 mm²	2.5 mm²
2.5 mm²	2.5 mm²	4.0 mm²
4.0 mm²	4.0 mm²	6.0 mm²

Note:
For cable lengths below 7.5 m in the vehicle, at least the same cable cross-sections as in the heater wiring harness must be used. For cables lengths between 7.5 m and 15 m in the vehicle, the cable cross sections must be enlarged according to the table.

Line colours	
bl	blue
br	brown
ye	yellow
ge	green
gr	grey
or	orange
rd	red
bl	black
vi	violet
wt	white
rd/wt	red/white

Fig. 607 Volvo system connection to wiring harness 11111293_



Item	Description
BA	Operating display max. 5W
BM	Combustion air motor
DVW	Nozzle block preheater
F1	Vehicle blade-type fuse 25 A according to DIN 72581 part 3
F2	Vehicle blade-type fuse 25 A according to DIN 72581 part 3
F3	Vehicle blade-type fuse 5A according to DIN 72581 part 3
FA	Flame display max. 5W
HS	Main switch
MV	Solenoid valve
S1	Main switch - heater On/Off
S2	Switch - operating mode - saving mode
S3	Switch - UP On/Off (without heating function)
S4	Switch UP 2 On/Off
UP	Circulating pump
UPFA	External circulating pump actuation
UPL	Optional circulating pump display for testing, max. 5W

Legend

Item	Description
BA (Test)	Optionally connectible lamp for diagnosis purposes, max. 5W
ZFG	Electronic ignition unit

Legend (cont.)

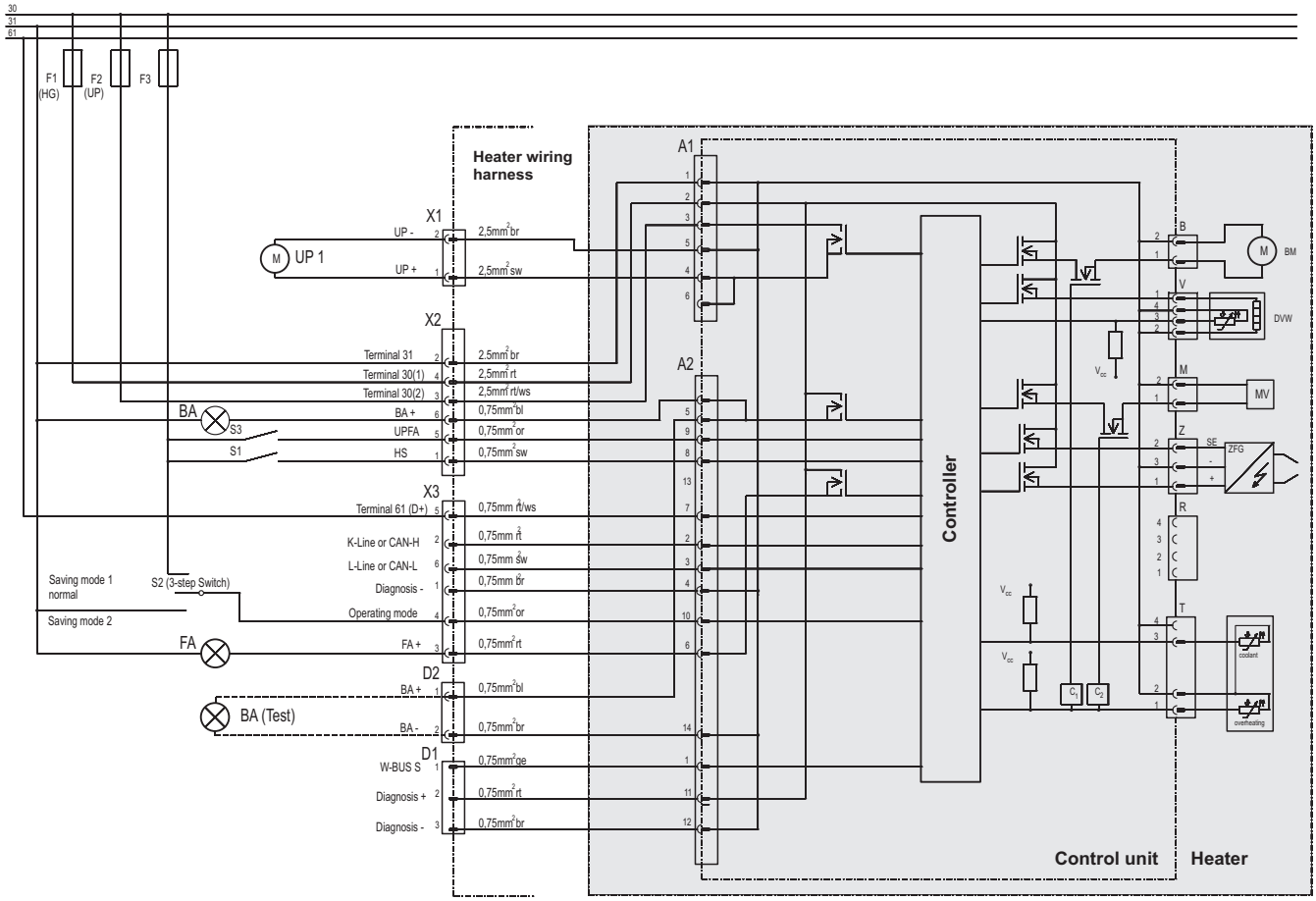
Cable cross-section in heater wiring harness	Cable cross section for cable lengths in vehicle	
	< 7.5 m	7.5 - 15m
0.75 mm²	0.75 mm²	1.5 mm²
1.0 mm²	1.0 mm²	1.5 mm²
1.5 mm²	1.5 mm²	2.5 mm²
2.5 mm²	2.5 mm²	4.0 mm²
4.0 mm²	4.0 mm²	6.0 mm²

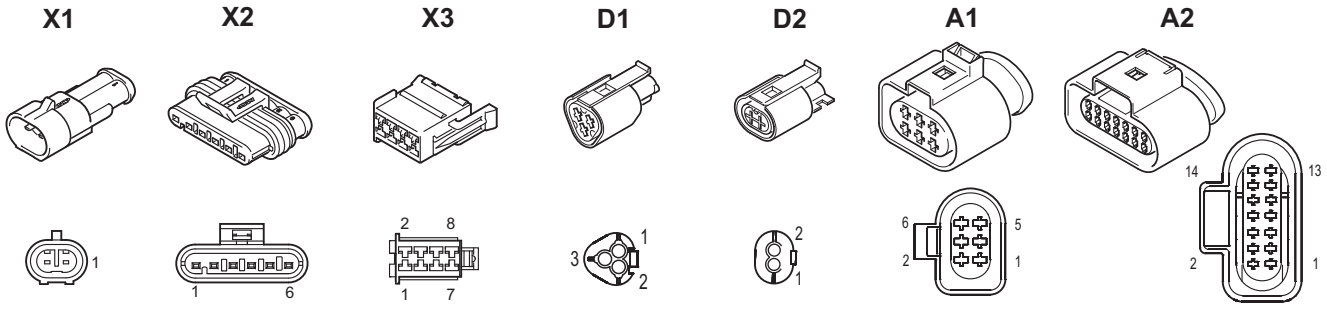
Note:

For cable lengths below 7.5 m in the vehicle, at least the same cable cross-sections as in the heater wiring harness must be used. For cables lengths between 7.5 m and 15 m in the vehicle, the cable cross sections must be enlarged according to the table.

Line colours	
bl	blue
br	brown
ye	yellow
ge	green
gr	grey
or	orange
rd	red
bl	black
vi	violet
wt	white
rd/wt	red/white

Fig. 608 Solaris system connection to wiring harness 11112416_





Item	Description
BA	Operating display max. 5W
BM	Combustion air motor
DVW	Nozzle block preheater
F1	Vehicle blade-type fuse 15 A according to DIN 72581 part 3
F2	Vehicle blade-type fuse 15 A according to DIN 72581 part 3
F3	Vehicle blade-type fuse 5A according to DIN 72581 part 3
FA	Flame display max. 5W
HS	Main switch
MV	Solenoid valve
S1	Main switch - heater On/Off
S2	Switch - operating mode - saving mode
S3	Switch - UP On/Off (without heating function)
UP	Circulating pump
UPFA	External circulating pump actuation
UPL	Optional circulating pump display for testing, max. 5W

Legend

Item	Description
BA (Test)	Optionally connectible lamp for diagnosis purposes, max. 5W
ZFG	Electronic ignition unit

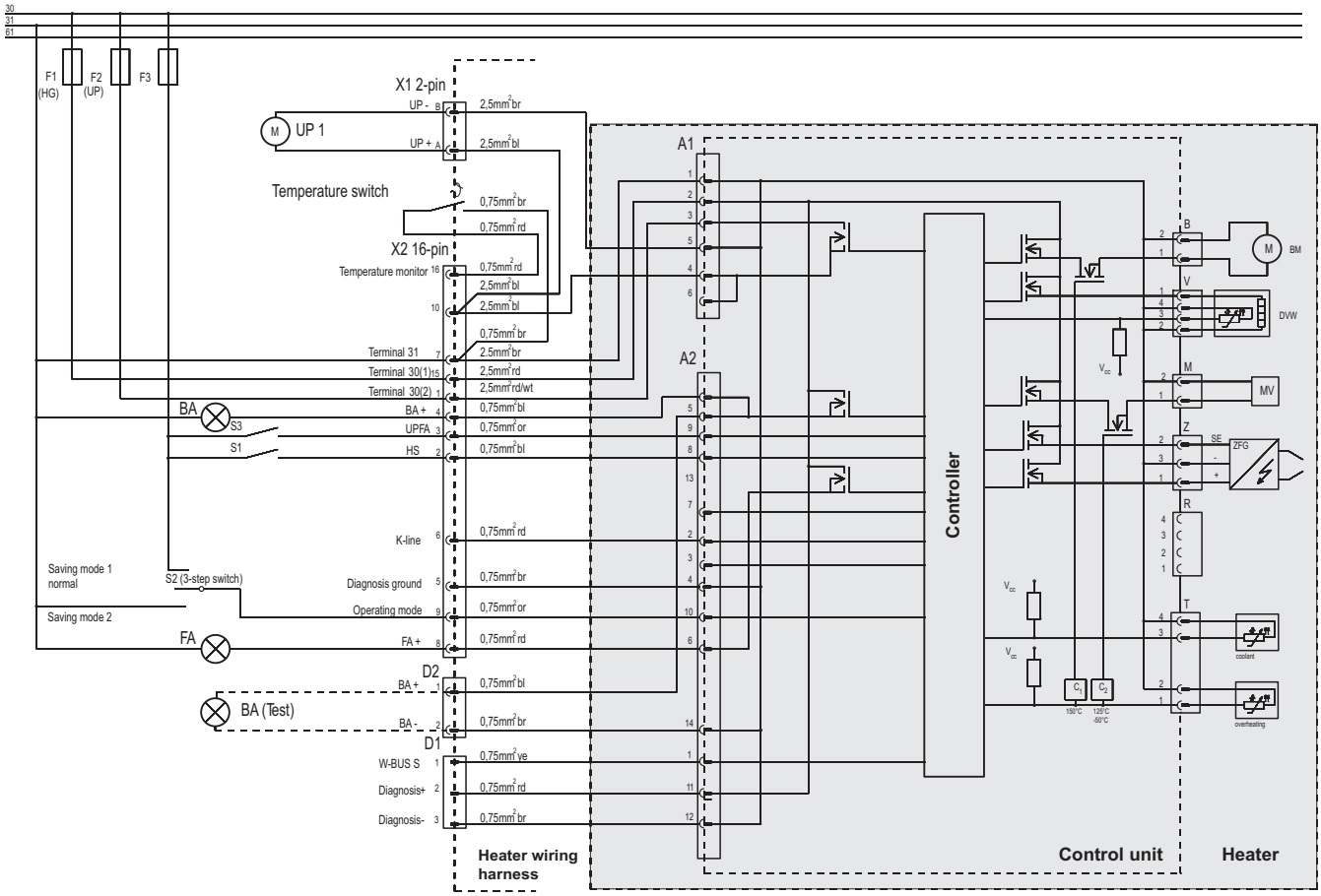
Legend (cont.)

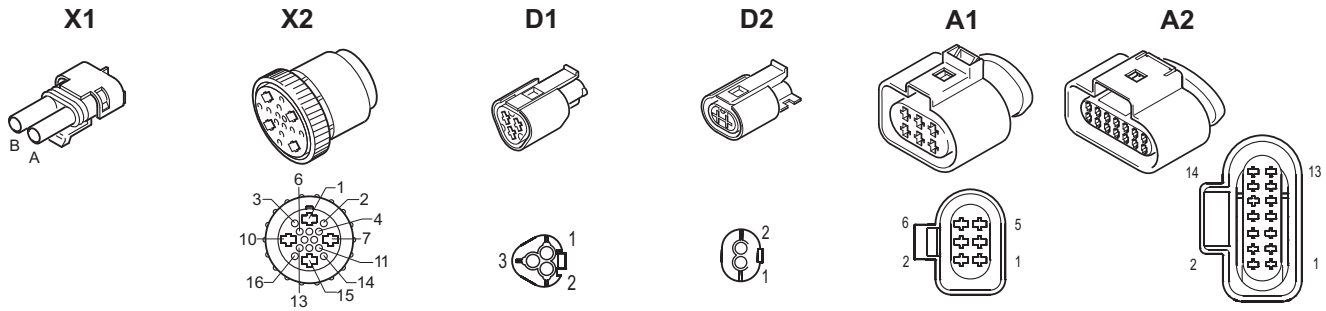
Cable cross-section in heater wiring harness	Cable cross section for cable lengths in vehicle	
	< 7.5 m	7.5 - 15m
0.75 mm²	0.75 mm²	1.5 mm²
1.0 mm²	1.0 mm²	1.5 mm²
1.5 mm²	1.5 mm²	2.5 mm²
2.5 mm²	2.5 mm²	4.0 mm²
4.0 mm²	4.0 mm²	6.0 mm²

Note:
For cable lengths below 7.5 m in the vehicle, at least the same cable cross-sections as in the heater wiring harness must be used. For cables lengths between 7.5 m and 15 m in the vehicle, the cable cross sections must be enlarged according to the table.

Line colours	
bl	blue
br	brown
ye	yellow
ge	green
gr	grey
or	orange
rd	red
bl	black
vi	violet
wt	white
rd/wt	red/white

Fig. 609 IRIZAR system connection to wiring harness 11116897_





Item	Description
BA	Operating display max. 5W
BM	Combustion air motor
DVW	Nozzle block preheater
F1	Vehicle blade-type fuse 25 A according to DIN 72581 part 3
F2	Vehicle blade-type fuse 25 A according to DIN 72581 part 3
F3	Vehicle blade-type fuse 5A according to DIN 72581 part 3
FA	Flame display max. 5W
HS	Main switch
MV	Solenoid valve
S1	Main switch - heater On/Off
S2	Switch - operating mode - saving mode
S3	Switch - UP On/Off (without heating function)
UP	Circulating pump
UPFA	External circulating pump actuation
UPL	Optional circulating pump display for testing, max. 5W

Legend

Item	Description
BA (Test)	Optionally connectible lamp for diagnosis purposes, max. 5W
ZFG	Electronic ignition unit

Legend (cont.)

Cable cross-section in heater wiring harness	Cable cross section for cable lengths in vehicle	
	< 7.5 m	7.5 - 15m
0.75 mm²	0.75 mm²	1.5 mm²
1.0 mm²	1.0 mm²	1.5 mm²
1.5 mm²	1.5 mm²	2.5 mm²
2.5 mm²	2.5 mm²	4.0 mm²
4.0 mm²	4.0 mm²	6.0 mm²

Note:
For cable lengths below 7.5 m in the vehicle, at least the same cable cross-sections as in the heater wiring harness must be used. For cables lengths between 7.5 m and 15 m in the vehicle, the cable cross sections must be enlarged according to the table.

Line colours	
bl	blue
br	brown
ye	yellow
ge	green
gr	grey
or	orange
rd	red
bl	black
vi	violet
wt	white
rd/wt	red/white

Fig. 610 Van Hool system connection to wiring harness 11112417_

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 run-down. 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.

Mandatory maintenance:

- Fuel pump and fuel lines must be immediately replaced when leaking, otherwise every 5 years.

NOTE:

If bio diesel or FAME is used, the fuel pump and fuel lines must be replaced according to the latest technical information.

You can find the latest overview on the Spheros homepage under Service / Technical Updates / Heating systems.

Recommended maintenance:

- 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.
- Mandatory is:
  Yearly atomizer nozzle replacement.
  The atomizer nozzle is a consumable (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.
- The heater should be inspected in periodic time intervals, latest at the beginning of the heating period by a Spheros Service Center.

7.2.1 CO_2 content adjustment

A modification of the factory-adjusted burner motor speed and thus of the exhaust CO_2 content is permitted.
The burner motor speed can be adjusted using STT diagnosis.
An exhaust measurement device (CO_2 measurement device) is necessary for the adjustment.

The exhaust CO_2 content must be measured and the combustion air volume may have to be adjusted:
- after burner repairs.
- in case of combustion irregularities.
- in case of heavy sooting of the heat exchanger or other components during a functional test.
- after atomizer nozzle replacement.
- if heater is mainly operated above 1500 m.
- in case of modifications to the optional, application-dependent combustion air intake and exhaust line.

The STT diagnosis sequence defines the CO_2 content adjustment procedure.

The motor speed must be adjusted to ensure the CO_2 content in the exhaust is set to 9.5 + 1.5 Vol-%.

Adjustment procedure
- Switch heater on.

NOTE:
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. The exhaust fume temperature should be measured at the same location.
Increased exhaust temperature may indicate a sooted heat exchanger (see 5.5.2).

- After a combustion period of approx. 3 min. measure the CO_2 content in the exhaust and compare it to the target value in Table 701.
- Determine smoke number as needed: Target value according to Bacharach: ≤ 4.
- Connect the STT diagnosis adapter to the heater and a PC via the interface in the heater wiring harness. Start STT diagnosis, establish connection to the heater and open the Calibration menu.
- Obtain the next steps from STT diagnosis. Adjust the burner motor speed using STT diagnosis to achieve the target value for the CO_2 content.

A speed increase results in a reduction of the CO_2 content and vice versa.

NOTE:
An upper and lower speed limiting value is stored per heating capacity class in the control unit.
This should prevent incorrect adjustments during maintenance/service.
STT diagnosis displays the speed limiting values.

Table 701 CO_2 heater target values

Heater	S160	S230	S300	S350	S400
CO_2 target value	9.5 + 1.5 Vol.-%				

The CO_2 content depends on the fuel (viscosity) and the height above sea level (increase by approx. 0.1 Vol-% per 100 m height increase).
In the case that the CO_2 content cannot be properly adjusted, proceed as follows:

- Verify that fuel pump and atomizer nozzle comply with the heating capacity class.
- Verify burner motor speed.
- Inspect burner head on the air side for damage and replace as needed.
- Inspect fuel filter and fuel pump filter (screen) for contamination and replace as needed.
- Replace atomizer nozzle.
- Check fuel pump pressure acc. to 5.5.10 and if necessary readjust it or replace fuel pump.

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 must be scrapped and replaced.

It is permitted to remove components from the heater, while the heater is installed in the vehicle, assuming that sufficient space is available and no components will be damaged.

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.

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 with magnets

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. If necessary, disconnect the combustion air intake line from the heater.
3. Remove hood (4, Fig. 801).
4. Disconnect the temperature sensor plug.
5. Remove the cable grommet of the temperature sensor (5) from burner housing.

NOTE:

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

6. Unscrew fuel lines and seal with blank plugs.
7. Unscrew nuts (2).
8. 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 center alignment and correct fit.
2. Place nuts (2) and alternately tighten them slightly.
3. Tighten nuts (2).
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. Install the cable grommet of the temperature sensor (5) into the burner housing.
6. Connect the temperature sensor plug.
7. Install the hood (4).
8. If applicable, secure the combustion air intake line to the heater.
9. Connect heater with the vehicle electrical system and the circulating pump as needed.

ATTENTION:

The two combination nuts M8, connecting the burner head and the heat exchanger, must be tightened to 7.5 +1 Nm each and additional are to be secured using thread lock (Spheros ident. no.: 154245Z).

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

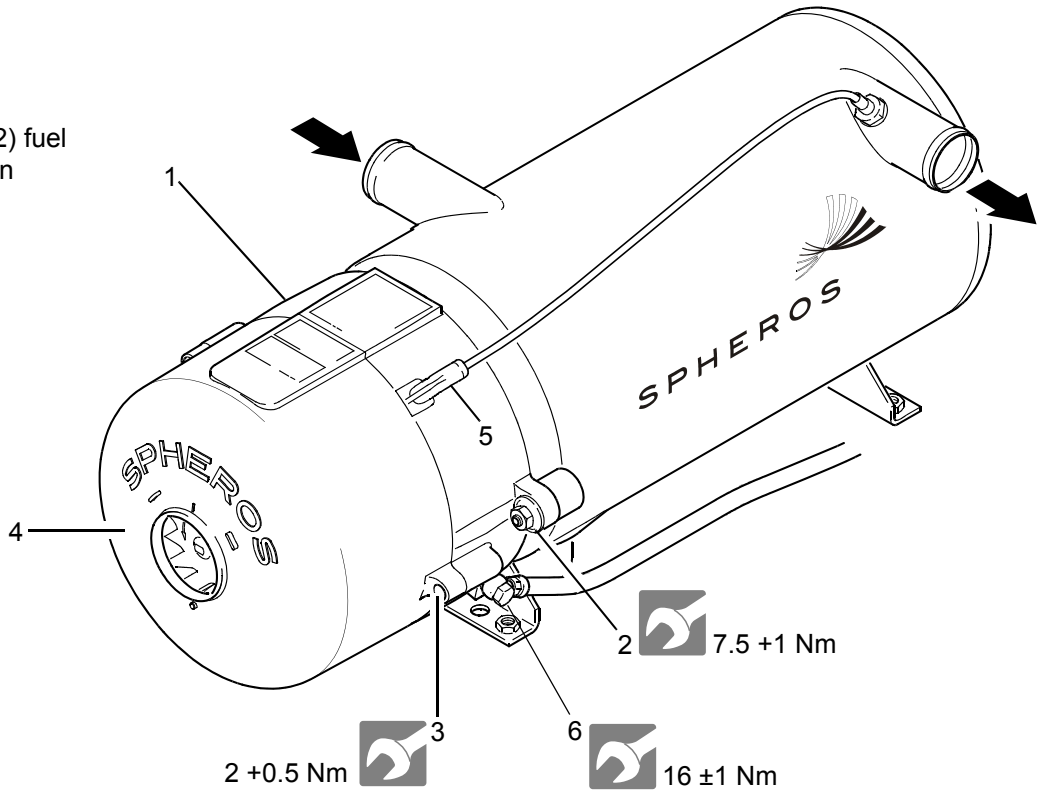


Fig. 801 Burner head / hood removal and installation

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

Caution!	Risk of scalds!

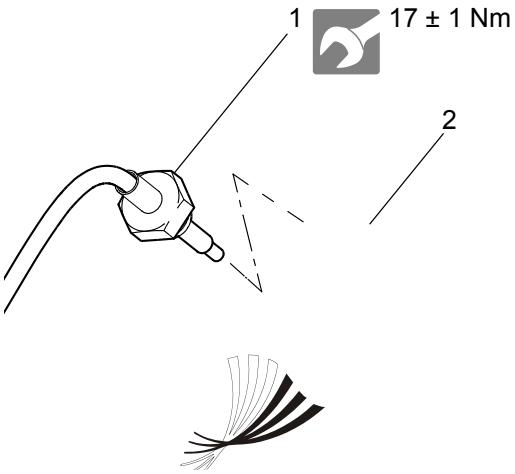
If the coolant temperature is increased, there is a risk of injury by contact with hot water!

Removal

1. Disconnect the heater from the vehicle electrical system and from the circulating pump as needed.
2. Remove hood (4, Fig. 801).
3. Disconnect the temperature sensor plug.
4. Remove the cable grommet of the temperature sensor (5) from burner housing.
5. Unscrew and remove temperature sensor (1, Fig. 802).

Installation

1. Manually screw temperature sensor (1, Fig. 802) into coolant outlet (2) .
2. Tighten temperature sensor (1).
3. Install the cable grommet of the temperature sensor (5) into the burner housing.
4. Connect temperature sensor plug.
5. Install the hood (4).
6. 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
- Motor cross member
- Control unit
- Coupling with magnets
- Main wiring harness plug
- Adapter wiring harness plug

Removal

1. Disconnect the heater from the vehicle electrical system.
2. Loosen screws (3, Fig. 801).
3. Remove hood (4).

Installation

1. Place hood (4, Fig. 801) in assembly position. Ensure center alignment, proper fit and seal towards heater wiring harness and cable grommet of the temperature sensor.
2. Insert screws (3) and tighten them.
3. Connect the heater to the vehicle electrical system.

8.5 Combustion air fan removal and installation

NOTE:

For replacement of the combustion air fan the burner does not need to be removed.

ATTENTION:

The shaft circlip may not be overstretched.

Removal

1. Remove hood (see 8.4).
2. If applicable, remove the fan (2, Fig. 803). For this purpose remove the shaft circlip (1) from the motor shaft using suitable pliers.
3. Disconnect plug (4) of the burner motor from the control unit.
4. Remove screws (6) and pull motor (3) including the motor cross member (5) off the burner housing.
5. If necessary, remove motor cross member (5) from the burner motor (3). For this purpose loosen and unscrew screws (7) from the motor flange.

Installation

1. If necessary, reconnect the burner motor (3, Fig. 803) to the motor cross member (5). For this purpose align the burner motor with the motor cross member. Observe the motor cross member installation position. Screw the countersunk screws (7) into the dedicated recesses of the motor flange. Next tighten the countersunk screws (7).
2. If necessary, slide the coupling with magnets (10) onto the fuel pump shaft.
3. Align motor cross member (5) with the burner housing (11) observing the specified installation position of the motor cross member. Align the burner motor with the coupling by turning the burner motor shaft.
4. Secure burner motor and motor cross member with screws (6).
5. Tighten screws (6).
6. Connect plug (4) of the burner motor with the control unit.
7. If applicable, install the fan (2). For this purpose slide the fan onto the motor shaft and, using suitable pliers, secure a new shaft circlip (1) onto the motor shaft.
8. Install hood (see 8.4).

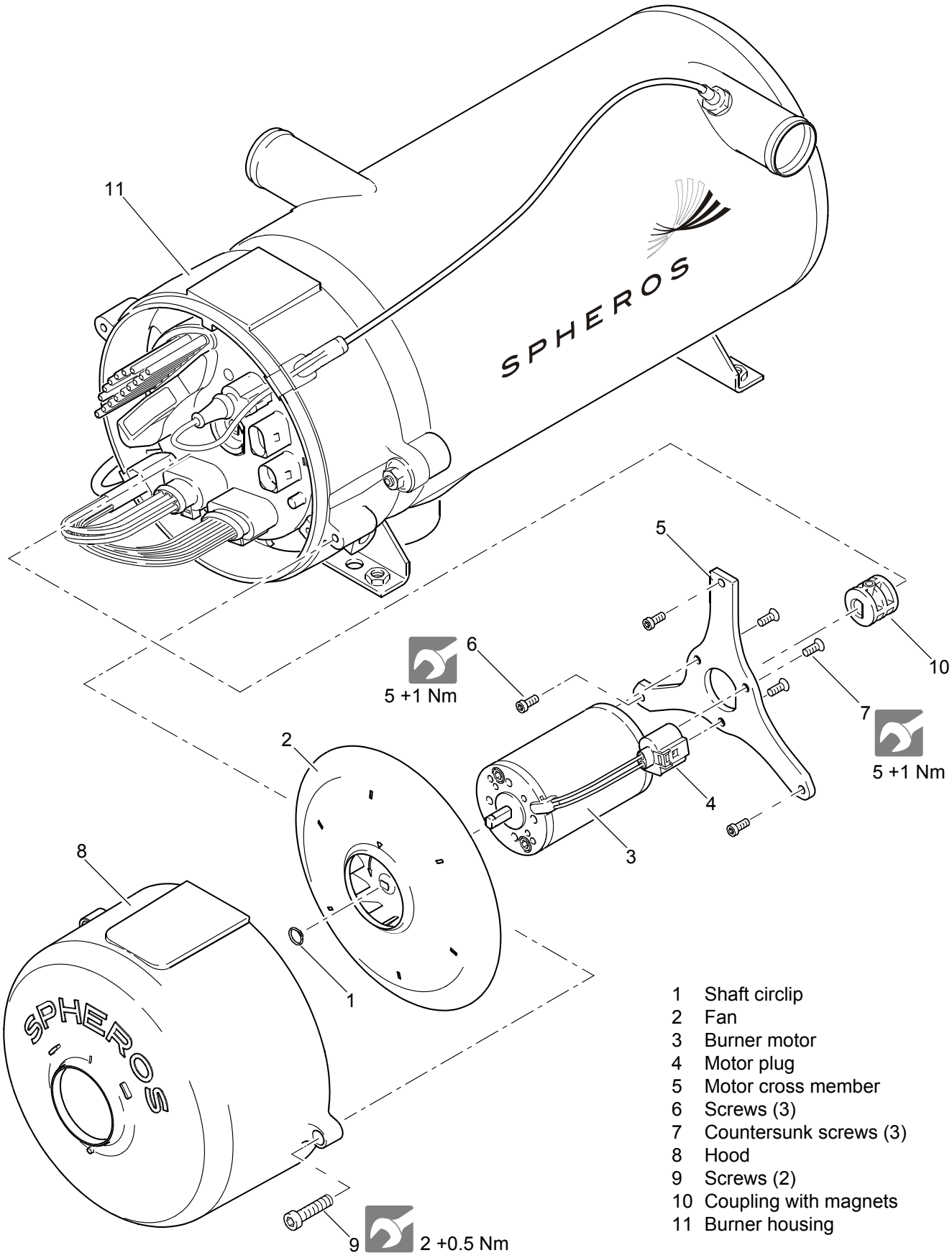


Fig. 803 Combustion air fan removal and installation

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. Tighten screws (4).
3. Fit disc (5) onto the nozzle holder of the fuel pump (9, Fig. 805) and align with the flame detector in the control unit (14) and the electronic ignition unit.
4. Fit the ignition electrode (2, Fig. 804).
5. Install burner (see 8.2).

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

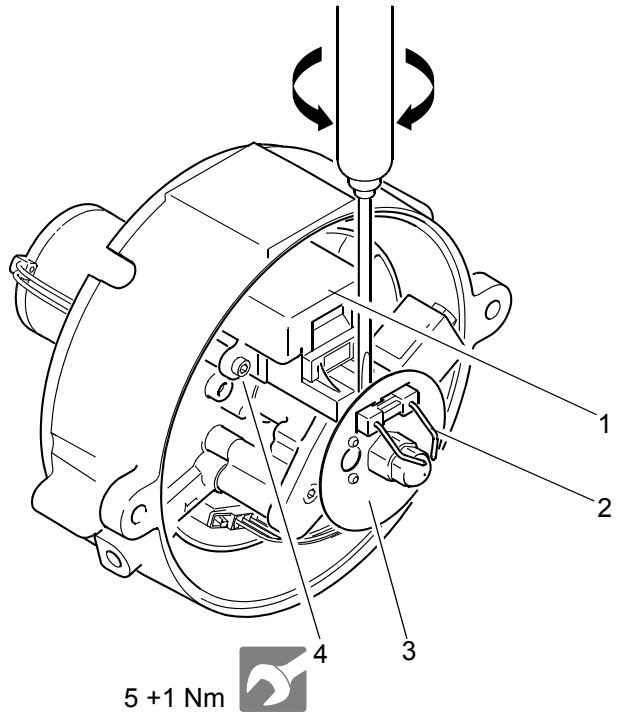


Fig. 804 Removal of the electronic ignition unit / ignition electrode

1 Electronic ignition unit
2 Screw (2)
3 Ignition electrode
4 Atomizer nozzle
5 Disc
6 Solenoid valve
7 Nozzle block preheater, optional
8 Support
9 Fuel pump
10 O-rings (2)
11 Filter insert
12 Screws (3)
13 Burner housing
14 Control unit
15 Heater wiring harness
16 Temperature sensors assy
17 Coupling with magnets

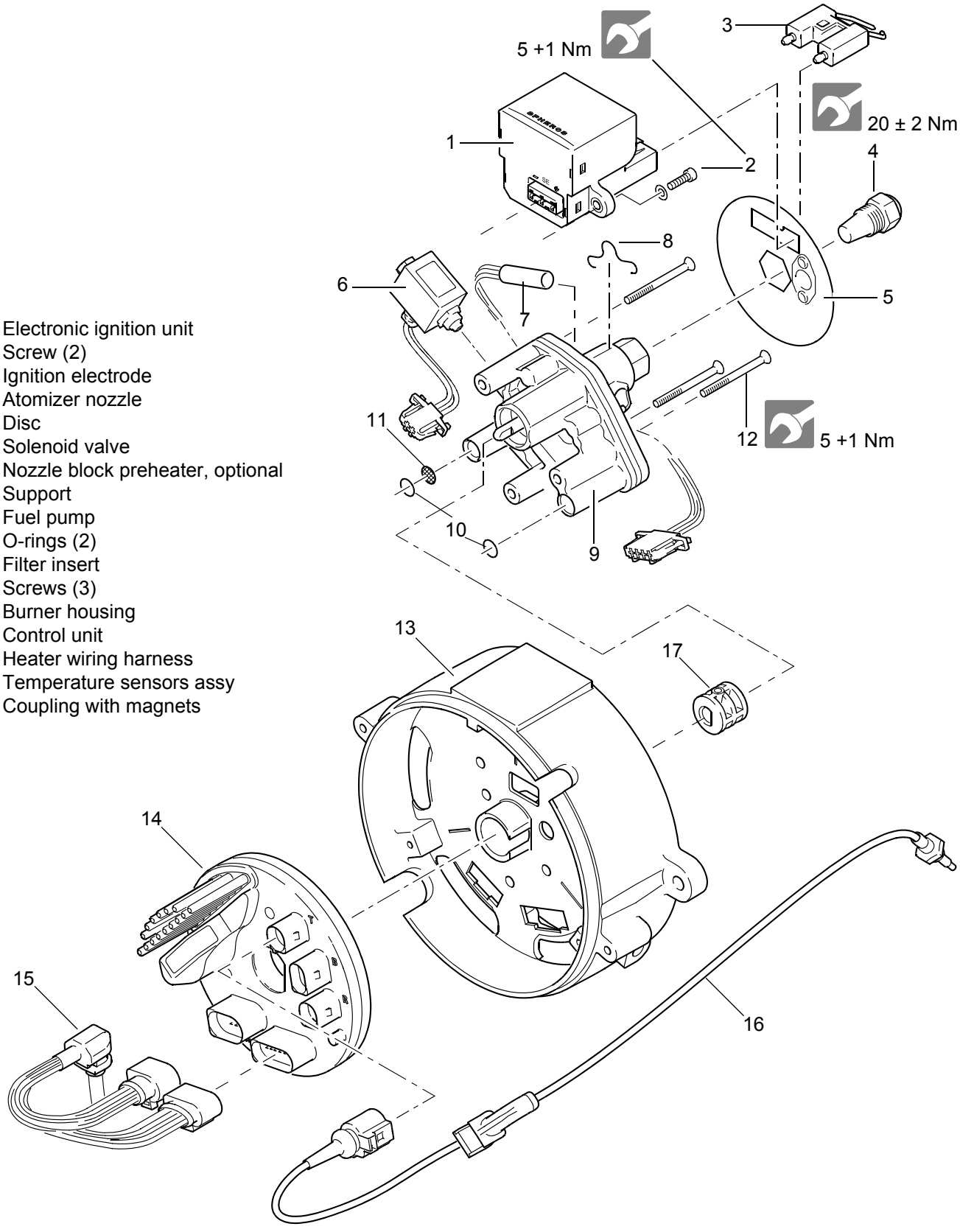


Fig. 805 Components removal and installation

8.7 Control unit removal and installation

Removal

1. Remove burner (see 8.2).
2. Disconnect solenoid valve plug (6, Fig. 806) and, if applicable, the optional nozzle block preheater (7) from the control unit (14).
3. Remove electronic ignition unit (see 8.6).
4. Remove combustion air fan (see 8.5).
5. Disconnect the heater wiring harness (15) from the control unit (14).
6. Carefully pull control unit (14) from the burner housing (13) and remove it.

Installation

1. Align control unit (14, Fig. 806) with the burner housing (13).
2. Carefully slide control unit (14) into the burner housing (13) as far as it will go.
3. Connect the heater wiring harness (15) to the control unit (14).
4. Install combustion air fan (see 8.5).
5. Install electronic ignition unit (1) (see 8.6).
6. Connect solenoid valve plug (6) and, if applicable, the optional nozzle block preheater (7) to control unit (14).
7. Install burner (see 8.2).

8.8 Fuel pump removal and installation

NOTE:

Make sure that any fuel leaking is immediately bound and professionally disposed of.

Removal

1. Remove burner (see 8.2).
2. Lift off ignition electrode (3, Fig. 806) from the electronic ignition unit by twisting a screwdriver sideways. (see Fig. 804)
3. Remove disc (5).
4. Disconnect the solenoid valve plug (6, Fig. 806) and the optional nozzle block preheater (7) from the control unit (14).
5. Remove and scrap screws (12).
6. Pull fuel pump (9) with the solenoid valve (6) off and remove it.
7. Remove and scrap O-rings (10) and filter insert (11).
8. If applicable, remove the nozzle block preheater (7). For this purpose, remove support (8) from the nozzle holder using suitable tools.
9. If necessary, remove the solenoid valve (6) from the fuel pump (9). (see 8.9)

Installation

1. If necessary, attach solenoid valve (6, Fig. 806) to the fuel pump (9). (see 8.9)
2. If applicable, install nozzle block preheater (7) and mount support (8) to the nozzle holder using suitable tools.
3. Attach new O-rings (10) and a new filter insert (11) to the fuel pump (9).
4. Slide the coupling with magnets onto the fuel pump shaft.

ATTENTION:

In order to avoid damage to the O-rings, to not twist fuel pump (9) during assembly.

New screws with coated threads must be used for installing the fuel pump.

5. Align fuel pump (9) with the burner housing (13) 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 (9) using new screws (with coated threads) (12) and tighten the screws.
7. Connect solenoid valve plug (6) and, if applicable, the optional nozzle block preheater (7) to control unit (14).
8. Fit disc (5) onto the nozzle holder and align it with the flame detector in the control unit (14) and the electronic ignition unit (1).
9. Fit ignition electrode (3).
10. Install burner (see 8.2).

1 Electronic ignition unit
2 Screw (2)
3 Ignition electrode
4 Atomizer nozzle
5 Disc
6 Solenoid valve
7 Nozzle block preheater, optional
8 Support
9 Fuel pump
10 O-rings (2)
11 Filter insert
12 Screws (3)
13 Burner housing
14 Control unit
15 Heater wiring harness
16 Temperature sensors assy
17 Coupling with magnets

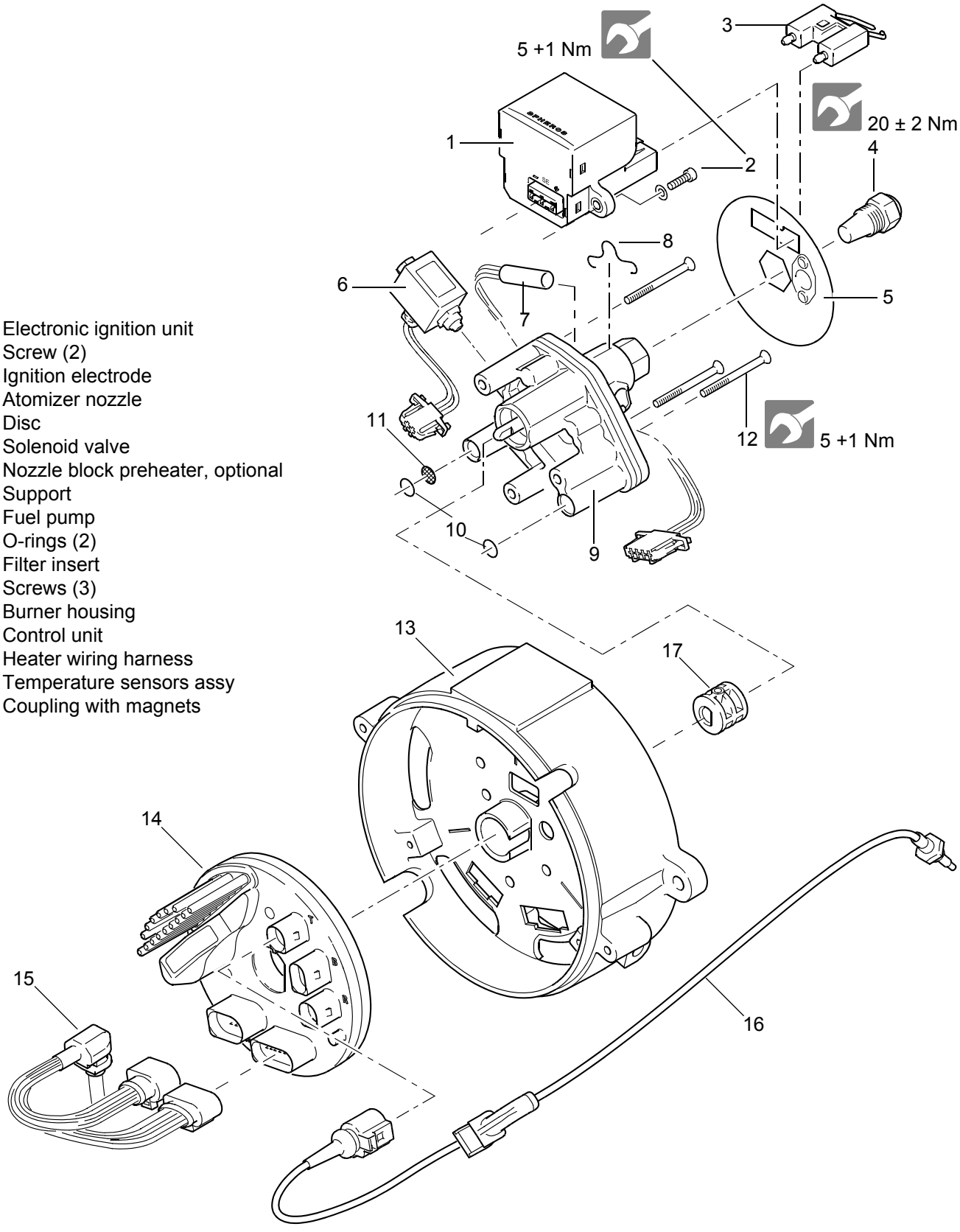


Fig. 806 Components removal and installation

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 bound and professionally disposed of.

Removal
1. Remove burner (see 8.2).
2. Lift off ignition electrode (1, Fig. 804) from the electronic ignition unit by twisting a screwdriver sideways. (see Fig. 804)
3. Remove disc (5, Fig. 806).
4. Disconnect the solenoid valve plug (6, Fig. 806) from control unit (14, Fig. 806).
5. Using suitable tools loosen the hexagon, wrench size 16 (6, Fig. 807) of the solenoid valve (6, Fig. 806) from the fuel pump (9, Fig. 806) and unscrew the solenoid valve (6).

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

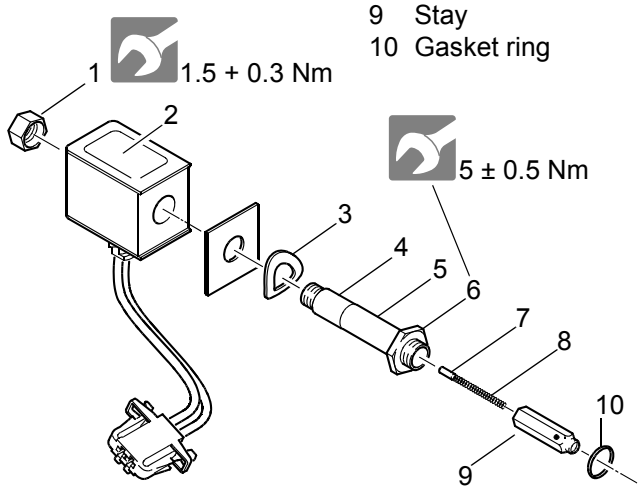


Fig. 807 Solenoid valve

Installation
1. Gasket ring (10, Fig. 807) towards the fuel pump must be replaced. Make sure stay, spring and lifter are correctly assembled, observe installation position (see Fig. 807).
2. Attach solenoid valve (6, Fig. 806) to the fuel pump (9).
3. Using suitable tools, tighten hexagon, wrench size 16 (6, Fig. 807) of the solenoid valve.
4. Connect the solenoid valve plug (6, Fig. 806) to the control unit (14).
5. Fit disc (5) onto the nozzle holder and align with the flame detector in the control unit (14) 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. 807) was loosened, then it must be tightened and subsequently secured using sealing wax.

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.
3. Remove disc (5, Fig. 806).

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 (9).

Installation
1. Screw in the atomizer nozzle (4, Fig. 806) and tighten it. If no nozzle wrench is used, a tool must be used to counter on the hexagon of the fuel pump nozzle holder (9).
2. Fit disc (5) onto the nozzle holder and align it with the flame detector in the control unit (14) and the electronic ignition unit (1).
3. Fit the ignition electrode (3).
4. 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. 808) 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. 808) 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. 808).
  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. 808.
  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)

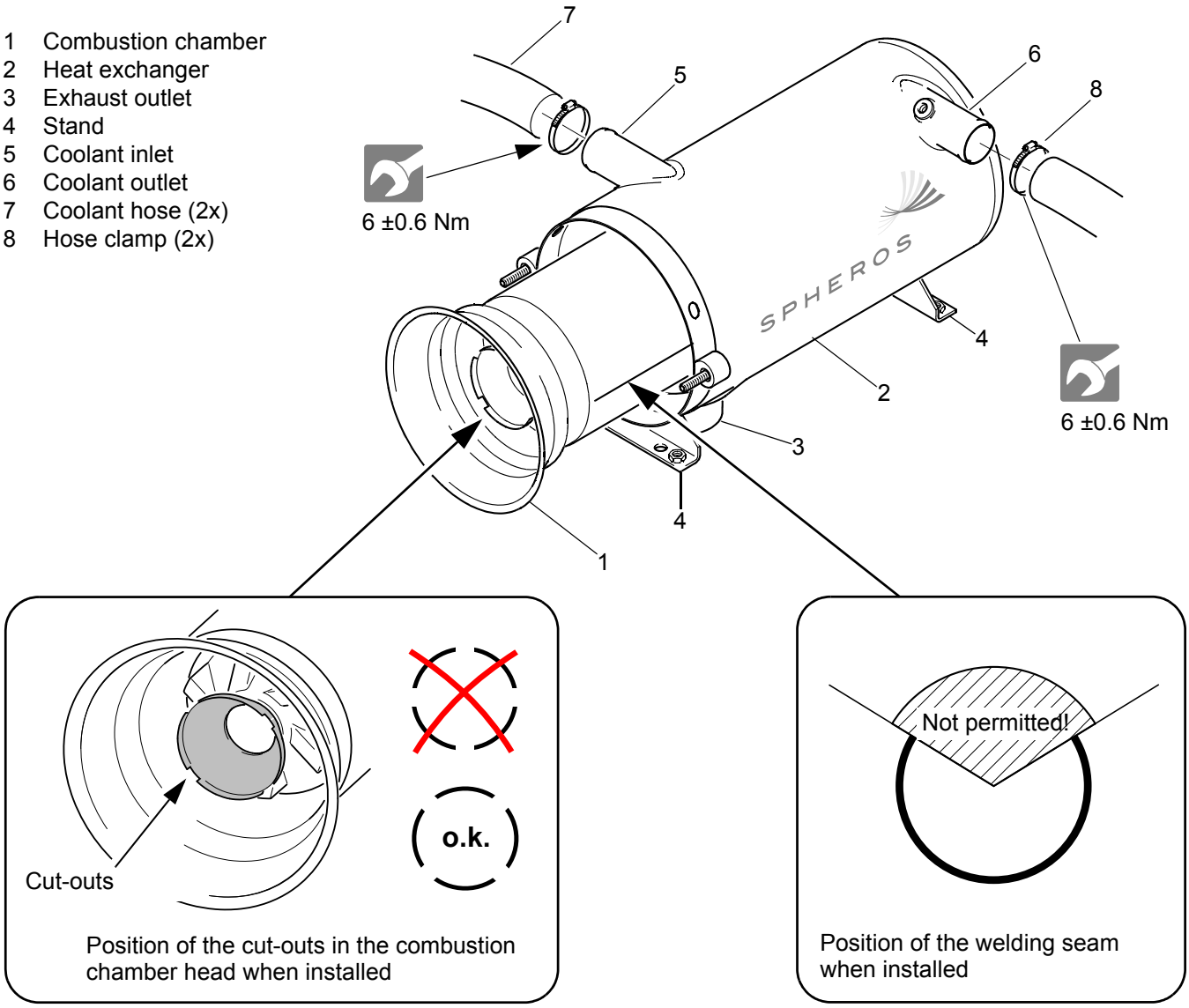


Fig. 808 Combustion chamber/heat exchanger removal/installation

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. 808) out of the heat exchanger (2) (see 8.11).
4. If necessary, loosen the exhaust line clamp on the exhaust outlet (3).
5. If available, 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. Caution if coolant temperature is increased.

Installation
1. Bring heat exchanger (2, Fig. 808) 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 available, open water taps.
5. Install burner (see 8.2).
6. Bleed coolant circuit (see 8.14.2).

8.13 Heater removal and installation

ATTENTION:

The fuel supply system must be subsequently bleed (see 8.14.1).

The coolant circuit must be subsequently bleed (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 system (see 8.14.1).
4. Bleed coolant circuit (see 8.14.2).

8.14 Start-up after burner or heater installation

The fuel system must be bleeded after burner installation. The coolant circuit and the fuel system must be bleeded after heater installation.
The vehicle manufacturer specifications must be observed. Coolant and fuel connections must be checked for leak-tightness and tight fit during the test run.
If a malfunction occurs during heater operation, troubles-hooting must be performed (see chapter 5).

8.14.1 Bleeding the fuel system

The whole fuel supply system including the fuel filter must completely filled with fuel before initial start-up.

NOTE:
Never use the fuel pump to fill / bleed the fuel system!

ATTENTION:

In the event no fuel comes to the fuel pump during initial start-up, there is a risk that the fuel pump will be damaged!

8.14.2 Bleeding of the coolant circuit

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

Caution!	Risk of scalds!

If the coolant temperature is increased, there is a risk of injury by contact with hot water!

ATTENTION:

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 4.6) 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.

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 section 4 may not be exceeded during storage.

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). In principle the regulations of the vehicle manufacturers must be adhered. If there no such regulations, Spheros prescribes the here shown maintenance intervals for common applications.
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.

Address of the operator	Date of maintenance
	Vehicle data

Heater data

Type of heater: Ident. no.: Serial no.:	Operating/ control device data acc. to diagnosis STT (Spheros Thermo Test)	Date of commision

Fuel	Diesel fuel ☐	Biodiesel ☐	Heating oil EL ☐

Check / Maintenance	Important notes	Check result OK	Check result not OK	Measured values, accomplished repairs
1. Electrical connections a) Examine electrical plug connections and the wiring harness for visible damages, replace as required.		☐	☐	
2. Heat exchanger a) Check for external damage, discoloration caused by overheating and leaks. b) Clean the heat exchanger inside and outside, remove soot and debris.	Determine overheating cause as needed (e.g. water circulation system), check overheat protection.	☐ ☐	☐ ☐	
3. Fuel system a) Inspect fuel lines and connections for leakage. b) Replace fuel filter insert with gasket. resp. replaceable filter.	Ensure connections to fuel flow and return lines are sealed tight! If biodiesel is used a semi annual filter change is prescribed by the manufacturer. Re-tighten screw connections and hose clamps.	☐ ☐	☐ ☐	

* For rail applications the maintenance record RAIL 9008722_ is to be considered.

Check / Maintenance	Important notes	Check result OK	Check result not OK	Measured values, accomplished repairs
c) Fuel pump / fuel lines **Note:** Observe technical information if biodiesel or FAME is used! d) Replace fuel screen with gasket in the pump.	Replace the fuel pump every 5 years, if biodiesel is used this interval is shortened **Technical Information (TI 2009 09) -> Biodiesel / FAME see www.spheros.de**	☐ ☐	☐ ☐	
4. Burner head a) Inspect combustion air intake opening for clear passage. b) Inspect hood for damage. c) Clean flame detector inspection glass (in the disk). d) Inspect condition of the ignition electrodes, if required adjust or replace them. e) Replace atomiser nozzle. f) Check solenoid valve for leaks.	Replace damaged parts. Activate combustion air motor using the diagnostic tool (STT), solenoid valve must be tight	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐	
5. Exhaust system a) Inspect exhaust line for clear passage or damage, clean or replace it as needed. b) Remove combustion chamber from heat exchanger, inspect for damage and contamination, clean and replace as needed. c) Insert combustion chamber and mount burner head. Ensure proper fit and tight connection to the heat exchanger. d) Combined nuts (M8) for burner head attachment, tightening torque 7.5 +1 Nm, secure them. e) Measurements Target values and procedures are outlined in the workshop manual Ambient temperature (° C) Exhaust temperature (° C) Thermo CO_2 (Vol.-%) Thermo S CO_2 (Vol.-%) Fuel pump pressure according to Workshop Manual	Secure them with locking compound Limits acc. to Regulation ECE-R 122 see technical data heater 9.5% … 10.5% at 24V 9.5% … 11.0% at 24V 10 bar	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	
6. Water system a) If available, inspect, clean as needed or replace water filter insert.		☐	☐	
7. Functional check a) If available, open shut-off valve of the fuel return line and water line. b) Check fault memory, clear it as needed using the diagnostic tool (STT). c) Check heater functionality. **Attention:** During the maintenance, check all screw connections for tightness (for corresponding torque values see Workshop Manual).	after at least 10 min heater operation	☐ ☐ ☐	☐ ☐ ☐	

* For rail applications the maintenance record RAIL 9008722_ is to be considered.

Spheros Service Worldwide

NORTH AMERICA

USA
Spheros North America Inc.
☎ ++1 734 218 7350
✉ technical@spheros.us
Toll Free: ++1-888-960-4849
www.spheros.us

MIDDLE & SOUTH AMERICA

Mexico
Spheros México S.A. de C.V.
☎ +55 (54) 2101 5700
✉ spheros@spheros.com.br
www.spheros.com.br

Brasil
Spheros Climatização
do Brasil S/A
☎ +55 (54) 2101 5700
✉ spheros@spheros.com.br
www.spheros.com.br

Columbia
Spheros Thermosystems
Colômbia
☎ +55 (54) 2101 5700
✉ spheros@spheros.com.br

EUROPE

Germany
Spheros Europa GmbH
☎ +49 8105 7721 887
✉ service@spheros.de
www.spheros.de
www.spheros.eu

Finland
Spheros-Parabus Ltd.
☎ +358 2 436 60 00
✉ info@parabus.com
www.parabus.com

Turkey
Spheros Termo
Sistemleri A.S.
☎ +90 (212) 672 15 90
✉ info@spheros.com.tr
www.spheros.com.tr

Ukraine
Spheros Elektron GmbH
☎ +380 (322) 91 15 64
www.spheros.electron.ua

ASIA

Turkey
Spheros Termo
Sistemleri A.S.
☎ +90 (212) 672 15 90
✉ info@spheros.com.tr
www.spheros.com.tr

UAE Dubai
Spheros Middle East
☎ +971 4 8860 665
✉ spheros@eim.ae

India
Spheros Motherson
Thermal System Ltd.
☎ +91 120 4712501
✉ info@spheros.in
www.spheros.in

AFRICA

South Africa
Spheros SA (Pty) Ltd.
☎ +27 (21) 703 7725
www.spheros.com

ASIA

China
Spheros (Suzhou) Ltd.
☎ +8613901457659 or
☎ +8613509686076
✉ service@spheros.com.cn

Hong Kong
Spheros Ltd.
☎ +852 3975 8300
www.spheros.asia
www.spheros.cn

Malaysia / Singapore
Senmas Holdings Sdn. Bhd.
☎ +603 3342 3631
✉ senmas.holdings@yahoo.com

Indonesia
PT .Klima Anlage Jaya
☎ +62 293 363591
✉ pt.klima.anlage.jaya@gmail.com

Thailand
Cherdchai Industrial Factory Co. Ltd.
☎ +66 44 240 550
✉motor@cherdchai.com

AUSTRALIA

Spheros Australia (Pty) Ltd.
☎ +61 (03) 97060084,
✉ info@spheros.com.au
www.spheros.com.au

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memos

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Spheros Europa GmbH
Valeo Thermal Bus Systems
Ihlenfelder Straße 148 · D-17034 Neubrandenburg
Tel. +49 (0) 8105 7721 0 · Fax +49 (0) 8105 7721 889
www.valeo.com · www.spheros.de · info@spheros.de

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