HEATING SYSTEMS

Thermo G 300

with control unit 1588

Workshop Manual

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1 Introduction

1.1 Content and purpose

This workshop manual is intended for the maintenance and repair of the water heaters (hereinafter heaters) Thermo G300 on the gas low pressure side.

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

Work on the heater must only be carried out by trained and / or by Spheros-trained personnel.

Any work on the gas supply line, for example when removing or installing the gas regulator, may only be carried out by persons with the appropriate official authorization.

1.2 Meaning of warnings and 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.

1.3 Further documentation to be used

In the **Thermo G Operating and Service Instructions** you will find all the necessary information as well as useful hints relating to the safe operation of the heater.
The **Thermo G Installation Instructions** contain all required information as well as useful hints for the correct installation of the heater.
Spare parts required during maintenance and repair, you can order using the **Thermo G Spare Parts List** at Spheros.
If necessary, Spheros will publish **Technical Information (TI)** for operation, maintenance or repair of the heater.
The **Heater Accessories Catalog** contains useful accessories for your heater installation.

All mentioned documents you will find in the download center on www.spheros.com.

1.4 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 in the individual sections or procedures with headings in capital letters.

1.4.1 General safety regulations

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

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

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

NOTE:

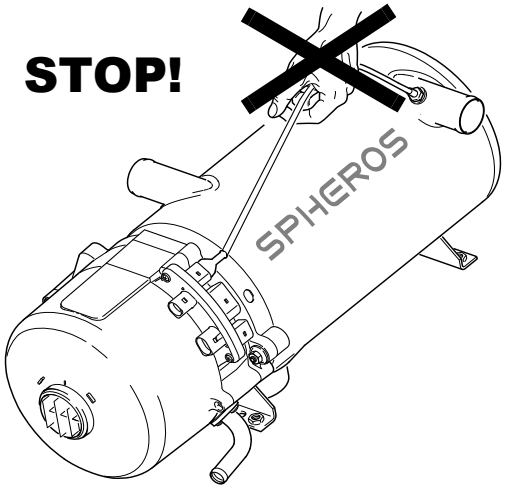
The Thermo G Operating and Service Instructions contain safety instructions and regulations to be followed for safe operation of the heater.

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

1.4.2 Other safety information

1.4.2.1 Temperature sensor

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



1.5 Suggestions for Improvement and change

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

service@spheros.com

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.

2.1 Heater

2.1.1 Altitude capability

The heater is adjusted in the factory, and without change of the CO_2 adjustment unlimited usable up to an altitude of 1500 m above MSL, above an altitude of 1500 m up to 2000 m an application with splash guard or combustion air intake line must be used.

Table 201 Technical data heater

Heater	
ECE type approval number	E1 122R-00 0447 / E1 10R-06 7263
Kind of design	Low-pressure gas burner
Heat output	30 kW ±10%
Fuel	CNG (natural gas) classes H/L
Combustion gas pressure when it enters the heater	-2.5 mbar
Fuel cosumption at CNG class H	< 2.95 kg/h
Rated voltage	24 Volt
Operating voltage range	20.5 ... 30 Volt
Rated power consumption without circulating pump	110 W
Current in standby mode	< 1 mA
Max. current at the circulating pump output	12A
Used gas pressure regulator	M96-E-SP
Max. ambient temperature for the heater and control device	Storage temperature -40 ... +120°C Operating temperature -40 ... +100°C
Permissible sucked in combustion air temp. (permanent)	-40 ... +60°C
Permissible operating overpressure	2.0 bar
Capacity of the heat exchanger	1.8 l
Minimum capacity of the water system	25.00 l
Minimum water flow	2400 l/h
CO_2 in exhaust gas at rated voltage	8.0 ... 9.0 Vol.-%
Switch thresholds	switches off at 82°C ±1K switches on at 72°C ±1K
Heater dimensions (tolerance ± 3 mm)	L 585 mm W 247 mm H 226 mm
Heater weight	19 kg

2.2 Gas pressure regulator

Table 202 Technical data gas pressure regulator

Gas pressure regulator	
Test certificate	ECE-R110.04, ECE-R10.06
Kind of gas	Natural gas (CNG) class H/L
Permissible oil content in gas	< 10 mg/m³
Input pressure	5 ... 220 bar
Output pressure	-0.25 ... -2.5 mbar
Pressure 1st stage	1.8 ... 3.5 bar
Pressure 2nd stage	0.65 ... 0.75 bar
Operating temperature	-40 ... +120°C
Sorage temperature	-40 ... +100°C
Rated voltage	24 V
Nominal coil power at rated voltage (2x)	24 W
Operating voltage range	20 ... 30 V
Dimensions (tolerance ± 3 mm)	L 150 mm W 130 mm H 170 mm
Weight	1.7 kg

2.3 Fuel

ATTENTION:
The heater may only be operated using natural gas (CNG).

As fuel natural gas (CNG) with a minimum methane content of 95 % is used.
If natural gas with a less methane content is used (natural gas of class L), the CO_2 level must be adjusted according to section 7.6.2 in chapter 7.

The max. oil content of the gas is 10 mg/m^3.

2.4 Circulating pump

All desired information about the Spheros circulation pumps can be found in the download center on www.spheros.com.

3 Description of assemblies and components

The water heater Thermo G 300 operates in conjunction with the on-board heating system

– to heat the passenger compartment
– to defrost the windscreen, and
– to pre-heat the water-cooled engines

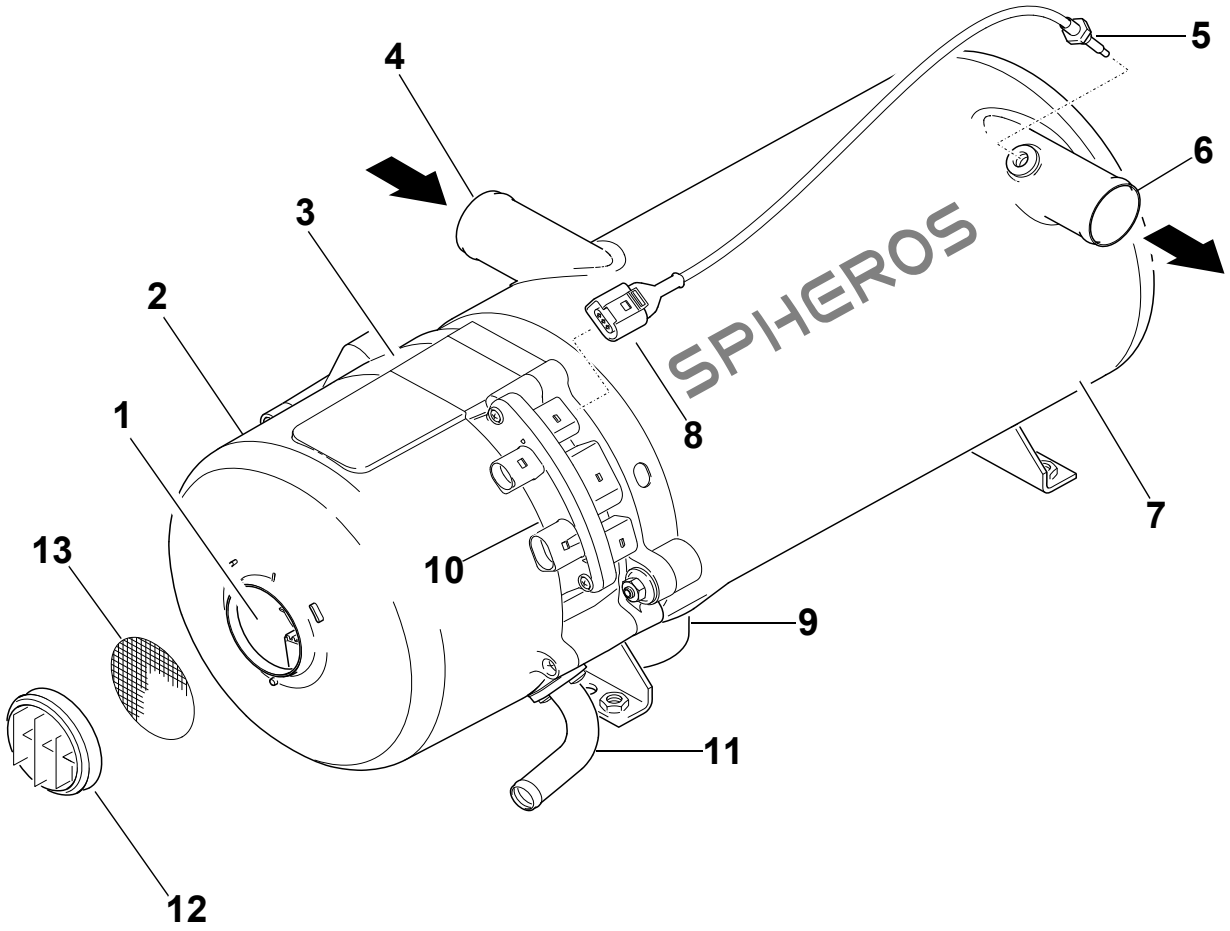
in busses.

The water heater operates independently of the vehicle's engine and is connected to the cooling system, the gas system and the electrical system of the vehicle. It is screw-mounted to the chassis of the vehicle or an additional crossmember.
The heat is generated by the combustion of the gas. Via the heat exchanger of the heater, the heat is dissipated to a coolant circuit. The adaptation to the changing demand of heat is reached by intermittent operation.
An integrated control device controls on the basis of the signals of a temperature sensor the on and off switching of the burner.

The heater Thermo G basically consists of:

– the burner head
– the combustion chamber
– the heat exchanger
– temperature sensor system

In addition, a circulating pump and a gas pressure regulator for the gas supply to the heater are installed in the vehicle.



1 Combustion air, intake
2 Hood
3 Fan housing
4 Coolant, inlet
5 Temperature sensor with integrated overheat protection
6 Coolant, outlet
7 Heat exchanger
8 Plug, sensor system
9 Exhaust outlet
10 Control device
11 Gas port
12 Mesh
13 Protective grid

3.1 Burner head

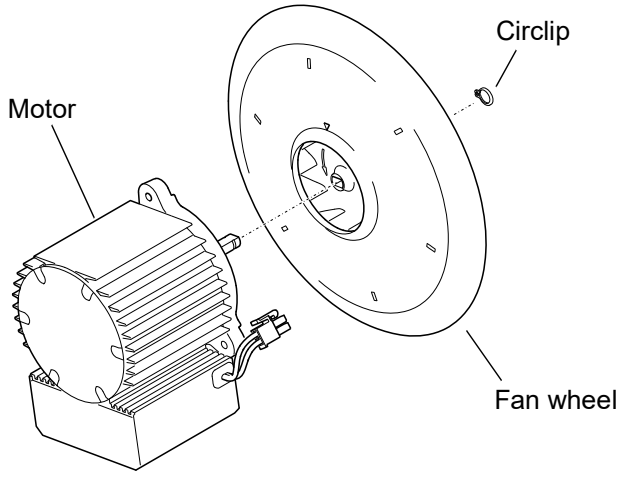
The burner head consists of the components

- combustion air fan
- control device
- mixing chamber
- heat protection cover
- ZF module with electronic ignition unit and ionization electrode
- flame tube

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.
By the air fan in addition, the required amount of gas is sucked in through the gas pressure regulator.

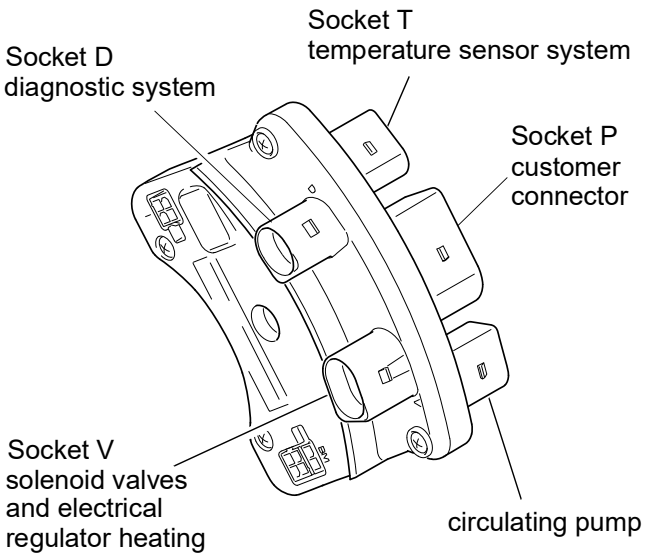
The air fan consists of the combustion air motor and the fan wheel. Air is sucked in through a protective grid in the hood and mixed with the gas in the mixing chamber.



If an air intake extension is used the combustion air is sucked in through this extension.

3.1.2 Control device

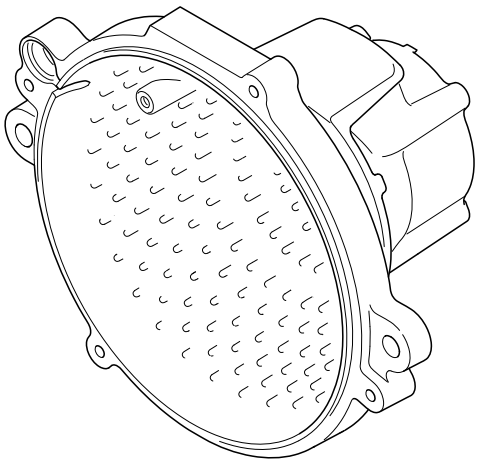
The control unit 1588 ensures the operating sequence and monitors the burner operation.



Control device 1588

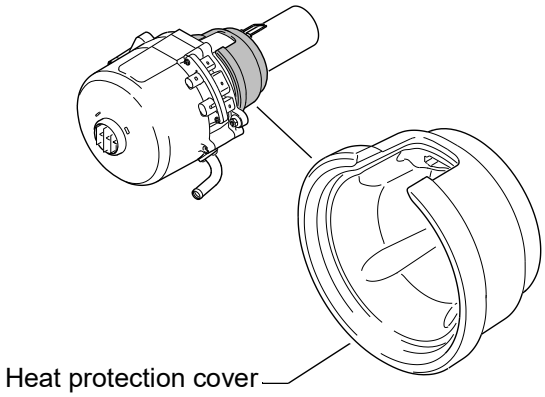
3.1.3 Mixing chamber

In the mixing chamber, the gas is mixed with the combustion air and then guided into the flame tube.
Across the surface of the mixing chamber evenly small bulges are distributed. On the one hand they generate turbulence for mixing of gas and combustion air and on the other hand they increase the flow-around surface of the mixing chamber. So it is cooled more effectively.



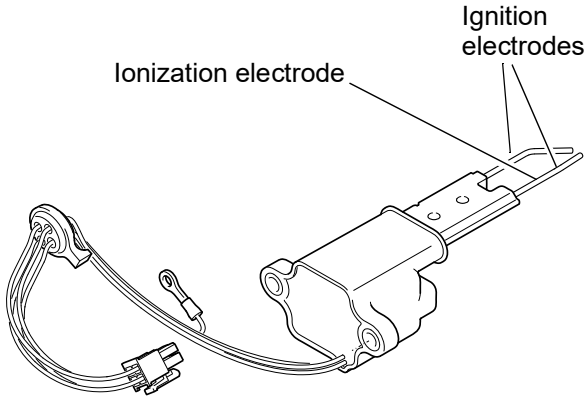
3.1.4 Heat protection cover

The heat protection cover is glued to the mixing chamber.



3.1.5 ZF Module with electronic ignition unit and ionization electrode

The electronic ignition unit induces the high voltage required for ignition of the gas-air mixture. Ignition is triggered by a high voltage spark between the two ignition electrodes.
The ZF module is used simultaneously for monitoring the flame in the combustion chamber. In principle it is an ionization flame guard.
As ionization electrode one of the two ignition electrodes of the ZF module is used. The counter-electrode is the flame tube, which is connected over a ground terminal to the housing with the control device.



ZF Module

The burning flame establishes an electrically conductive connection from the ionization electrode to the flame tube, and so to the ground potential. This ionization current is measured in the control device. Thereby, the presence or absence of a flame can be clearly detected.
The flame monitoring is part of the control.

3.1.6 Flame tube

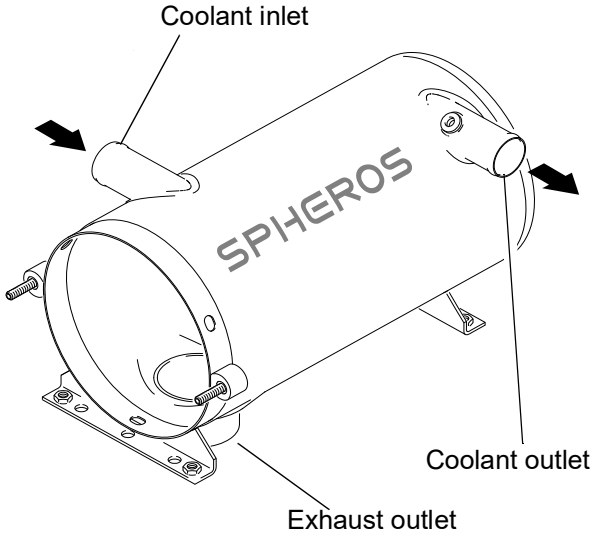
The flame tube ensures a defined, homogeneous flame ring in the combustion chamber.
For that, a plurality of outlet openings for the gas-air mixture across its surface are distributed in a defined pattern. Each opening acts like a nozzle.

3.2 Combustion chamber

In the combustion chamber the gas-air mixture is burned. It ensures that the generated during combustion hot exhaust gases are directed through the fins of the heat exchanger.

3.3 Heat exchanger

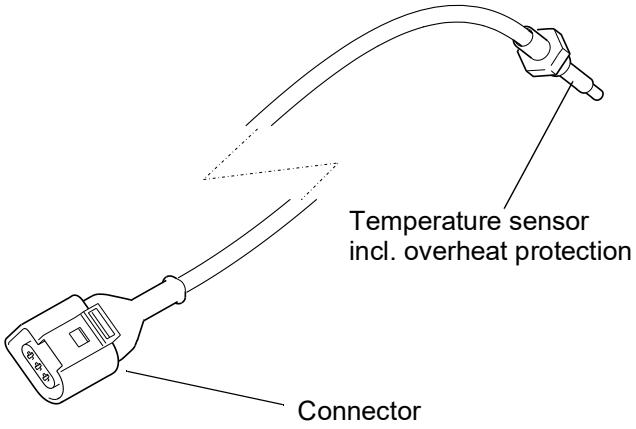
In the heat exchanger, the heat produced by the combustion is transferred to the coolant circuit.
Inside it has circularly arranged fins through which the hot exhaust gases generated during combustion are led.
In the outer shell flows the water of the coolant circuit through. There are two welded-on connection pieces, one for the coolant inlet and one for the coolant outlet.



3.4 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.

It is not necessary to manually reset the overheating protection.



3.5 Gas pressure regulator

Gas is supplied by means of the vehicle's gas supply system, in which the gas pressure regulator is incorporated. The gas pressure regulator regulates the storage pressure (max. 220 / min. 5 bar) downward in 3 steps to the required operating pressure. In the regulator at a pressure below atmospheric pressure the required quantity of gas is released by a diaphragm valve.

The gas pressure regulator has two solenoid valves (see Fig. below).
Solenoid 1 (MV1) opens the gas supply from the storage tank to the gas pressure regulator (high pressure branch).
Solenoid 2 (MV2) opens the gas supply from the gas pressure regulator to the heater (low pressure branch).
Both solenoid valves are controlled by the control device. Thus, the gas pressure regulator is integrated into the control concept of the heater.
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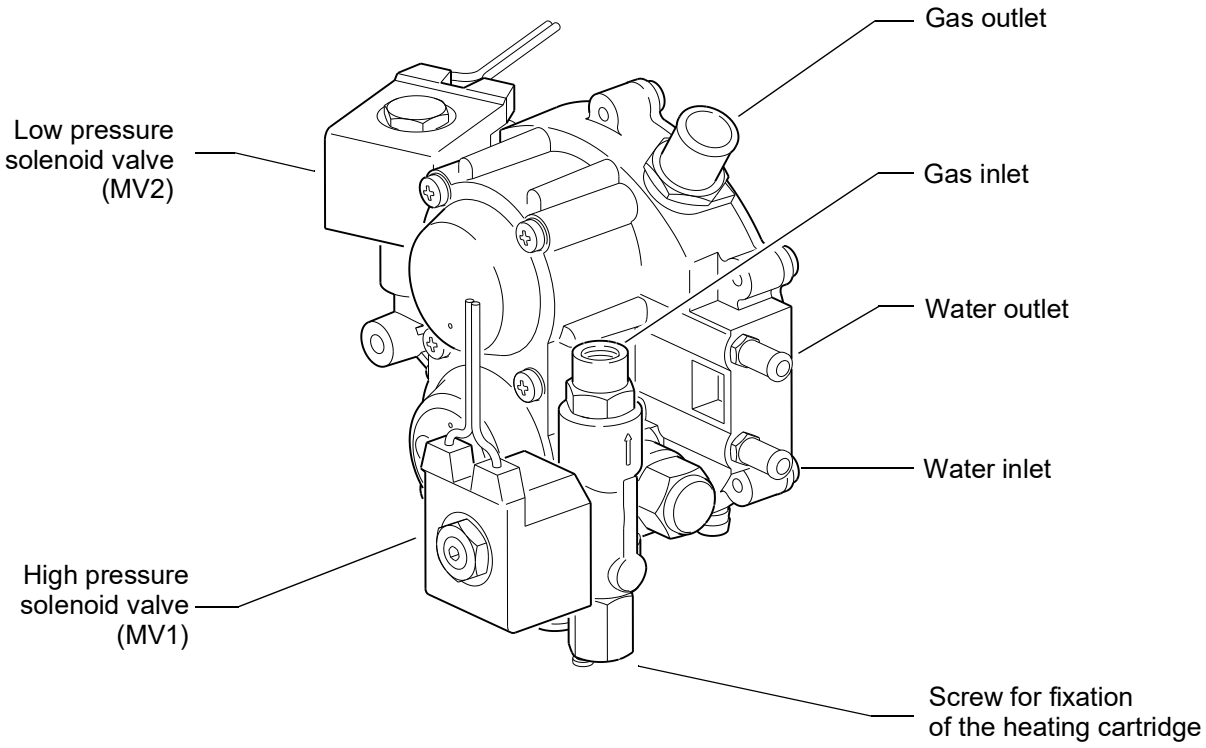


3.5.1 Heating of the gas pressure regulator

As the expansion of the compressed gas causes considerable cooling, the gas pressure regulator must be warmed up. This is accomplished by its integration into the cool water circuit.
By means of T-pieces the gas pressure regulator is connected with the water outlet and the water inlet at the heater.
Heated water is branched off at the water outlet and flows through the gas regulator. Then it re-enters the heater through the water inlet.

The gas regulator further has an electrical preheating (ERH). The heating cartridge is connected to a dedicated output on the control unit.
The ERH is activated at (water) temperatures below -20°C by the control unit. It is switched off again at a water temperature above -10°C. In addition, the initial cycle time from regularly 15 seconds increases to 40 seconds in water temperatures below -20°C.

3.6 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.

Further information on installation and operation of the circulating pump contain the Thermo G Installation instructions.

All service information regarding your Spheros circulating pump(s) can be found in the download center on www.spheros.com.

4 Heater functions

4.1 General heater functionality description

The heater function is based on the principle of the low-pressure gas burner and is controlled by a micro processor. At the same time the integrated control unit takes over all monitoring functions.

An electronically controlled motor drives a fan which sucks in combustion air and gas as fuel. Both are mixed in a mixing chamber. The gas-air mixture is then fed into the combustion chamber of the heater and burned there. The hot exhaust gases flow through a heat exchanger and thus provide heat to the water circuit connected to the heater.
The heater works intermittently, that means the gas burner is switched on and off according to the heat demand in the water cycle.

The ignition of the gas-air mixture takes place in the combustion chamber by high-voltage ignition sparks. The flame recognition is carried out by an in the ZF-module (electronic ignition unit) integrated flame guard. The principle is based on the measurement of the ionisation current through the flame.

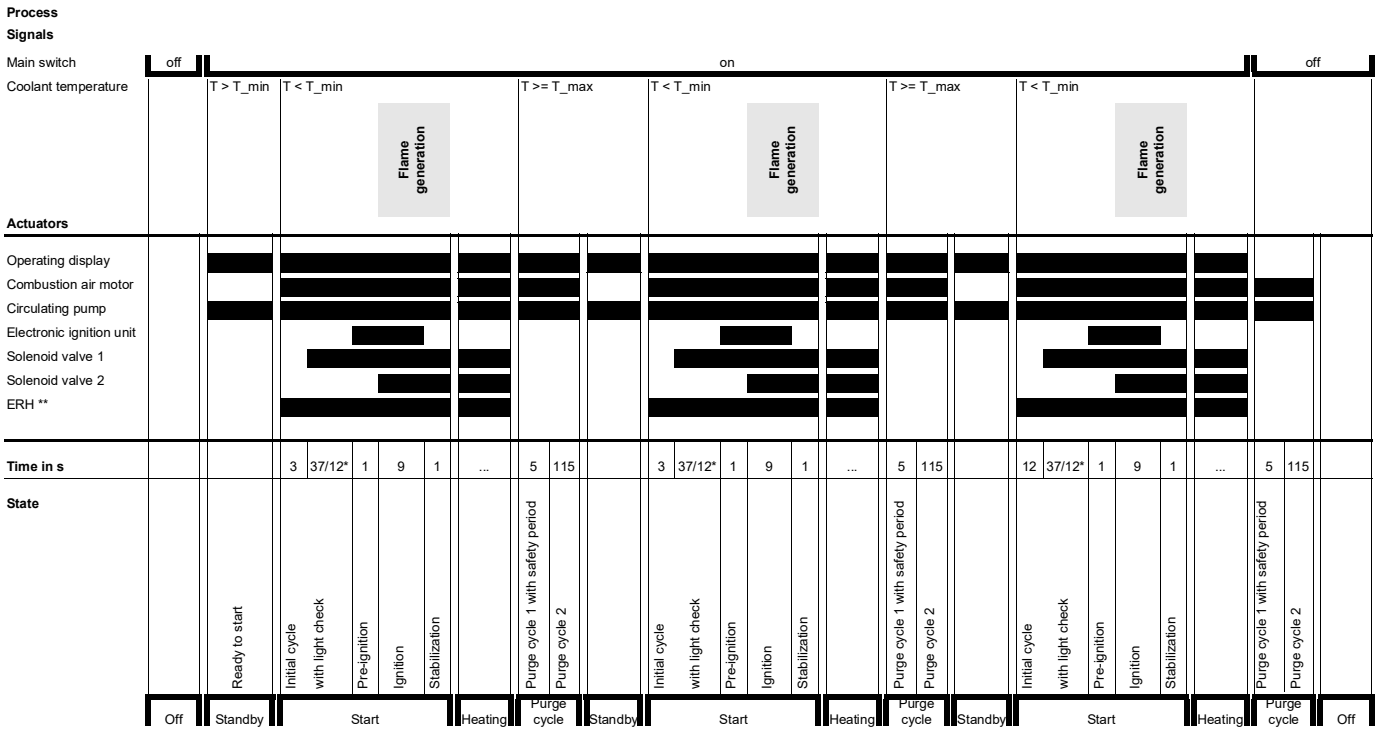
Depending on the equipment, the heater is switched on and off using a
- digital timer
- switch
- or climate control.

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

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

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

4.2 Operational heater sequence



* Coolant temperature below -20°C 40 seconds, otherwise 15 seconds, plus 0.3 seconds delayed switching of the combustion air motor and circulating pump
** On/Off depending on T

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. This takes approx. 15 seconds, if the coolant temperature is below -20°C approx. 40 seconds.
The initial cycle is used to start the combustion air motor and to query the flame monitoring. By the combustion air motor, the heat exchanger is flushed and at the same time a negative pressure to the gas pressure regulator is generated.
The solenoid valve 1 at the gas pressure regulator is switched on (open), so that the gas can flow from the gas tank into the gas pressure regulator.
Then, during the pre-ignition the electronic ignition unit is turned on to check its function, and to ensure an immediate ignition when the gas flows in.
Approximately 1 second later the solenoid valve 2 at the gas pressure regulator is turned on (open) and now gas can sucked in.
With the opening of the solenoid valve 2, the safety time begins (10 s).
When the gas-air mixture the combustion chamber has reached, it is ignited by the activated electronic ignition unit.
When the ignition of the gas-air mixture was successful, the flame guard detects the flame, and the system state will change to flame stabilization.
The state flame stabilization is used to stabilize the combustion and ends with the query / decision of the flame guard "flame". If yes, the system changes into the heating mode.

NOTE:
If during the start the main switch is turned off, or the water temperature rises above the upper temperature threshold, or a fault is detected, the system switches into the purge cycle.

4.2.2 Heating operation

After the flame is stabilized, the heater is in controlled operation.
The operation indication, the circulating pump, the combustion air motor, the solenoid valves 1 and 2 at the gas pressure regulator and the flame guard are active.
Once the upper switching threshold is exceeded, the heating operation is terminated and the purge cycle is initiated. The solenoid valves at the gas pressure regulator are closed, the flame extinguishes, but the combustion air fan and the circulating pump continue running.

After a safety period of 5 seconds the purge cycle 2 starts.
The flame monitoring is evaluated.
The purge cycle ends approx. after 115 seconds. The combustion air fan is switched off.
The heater is in a controlled break.
The operation indication, the flame guard and the circulating pump continue their operation.

NOTE:
If during the purge cycle 2 a “flame“ is recognized, the combustion air motor is switched off and an appropriate error message is given.
The operation indication, the flame guard and the circulating pump continue to run until the purge cycle 2 is terminated (after 115 seconds).

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

4.2.2.1 Gradient evaluation

In case of low coolant flow or poor coolant circuit venting the temperature 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.

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

4.2.3 Switching off

Switching the heater off ends the combustion process.
The operation indication goes off and the purge cycle is initiated.
The purge cycle cools down the components. This prevents that the residual heat in the heat exchanger, which is still present, overheats the components.
The solenoid valves 1 and 2 at the gas pressure regulator are closed, the flame extinguishes, combustion air fan and the circulating pump continue running.
After a safety period of 5 seconds the purge cycle 2 starts.
The flame monitoring is evaluated.
The purge cycle ends approx. after 115 seconds. The combustion air fan, the flame guard and the circulating pump are switched off.

4.3 Malfunction interlock and heater interlock

Malfunction interlocks and heater interlocks are distinguished.
The interlocks protect the heater and the surrounding vehicle assemblies against sequence errors after failure or malfunction of individual heater components.
In a heater interlock safety-related components are affected by the failure or malfunction. It may only be released by Spheros-trained personnel after eliminating the cause.

4.4 Malfunction interlock

If one of the malfunctions listed below occurs, the heater will initiate a fault shut-down, followed by malfunction interlock.
In the process a purge cycle up to 115 seconds duration can be executed.
An error code is outputted by means of flash impulses via the operating display.
In case of several sequential malfunction interlocks a heater interlock is initiated (see 4.5).

4.4.1 Malfunctions during switching-on and start procedure

Malfunction causes:
- Short circuit and/or interruption of electrical components (temperature sensor, combustion air motor, circulating pump, solenoid valves 1 and 2, electronic ignition unit of the ZF module, electrical regulator heating)
- Flame detection during intial cycle
- No start: No flame detection within 10 seconds after opening of the solenoid valve 2
- Heater operation outside the permissible operation temperature range.
- Voltage falling short of the low voltage threshold of approx. 20.5 V within a duration of 20 seconds after a heating request.
- Voltage exceeding the high voltage threshold of approx. 30 V within a duration of 6 seconds after a heating request (purge cycle only and after that the heater goes into the standby mode, no malfunction interlock).

NOTE:
As soon as the overvoltage is eliminated (6 seconds continuously), the heater restarts operation automatically according to functional sequence.

4.4.2 Malfunctions during heater operation

Malfunction causes:
- Short circuit and/or interruption of electrical components (temperature sensor, combustion air motor, circulating pump, solenoid valves 1 and 2, electronic ignition unit of the ZF module, electrical regulator heating)
- Heater operation outside the permissible operation temperature range.
- Flame interruption (more than 5 consecutive combustion faults by a flameout)

NOTE:
After a combustion fault by a flameout the heater is switched into the state „flushing“.
In this case, the gas supply is interrupted by the solenoid valve 2 at the gas pressure regulator, the combustion air motor continues to run.
If a component test has shown no errors and no flame is detected by the flame guard, after 10 seconds the pre-ignition is performed for the resumption of the combustion operation as during the normal start.

- Voltage falling short of the low voltage threshold of approx. 20.5 V within a duration of 20 seconds
- Voltage exceeding the high voltage threshold of approx. 30 V within a duration of 6 seconds (it takes place a purge cycle only, and after that the heater goes into the standby mode, no malfunction interlock)

NOTE:
As soon as the overvoltage is eliminated (6 seconds continuously), the heater restarts operation automatically according to functional sequence.

4.4.3 Malfunctions during purge cycle

Malfunction causes:
- Short circuit and/or interruption of electrical components (temperature sensor, combustion air motor, circulating pump, solenoid valves 1 and 2, electronic ignition unit of the ZF module, electrical regulator heating)
- Heater operation outside the permissible operation temperature range.
- Voltage falling short of the low voltage threshold of approx. 20.5 V within a duration of 20 seconds
- Voltage exceeding the high voltage threshold of approx. 30 V within a duration of 6 seconds (it takes place a purge cycle only, and after that the heater goes into the standby mode, no malfunction interlock)

NOTE:
As soon as the overvoltage is eliminated (6 seconds continuously), the heater restarts operation automatically according to functional sequence.

4.4.4 Malfunction interlock release and error clearance

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

Resetting a malfunction interlock leads to:
- Clear the lock of the outputs with errors, that means the outputs are activated again, an error can be detected again.
- The blink code output is reset, it will return to the output of the main switch state via the operation display.
- The fault counter status for the / fault is reset, that means, the fault counter can be increased for any errors again.

4.5 Heater interlock

The heater interlock overrides the standard malfunction interlock.

If the heater interlock is active, neither start nor purge cycle are executed after the heater is switched on again. Prior to restarting the heater, cause investigation and troubleshooting must be performed by Spheros-trained personnel.
After that the heater interlock can be released (see 4.5.1).

Heater interlock causes:
- Short circuit and/or interruption of the temperature sensor, overheat protection, solenoid valve 2
- Flame guard defective
- Overheat protection triggered
- Flame detection after „flushing“
- Flame detection during the purge cycle 2
- Control device fault or programming error
- Repeated malfunctions (8)
- Repeated flame interruptions (5)

4.5.1 Heater interlock release

ATTENTION:
Prior to releasing the heater interlock the cause of the fault must be eliminated!
The heater interlock release is permitted by Spheros-trained personnel only.

To release the heater interlock, the heater must be disconnected from the vehicle electrical system when it is on.
The heater interlock release is performed using the following sequence:

1. Correct the cause of the heater interlock.
2. Switch interlocked heater on.
3. Disconnect the switched on heater for > 10 seconds from the vehicle electrical system.
4. Reconnect the switched on heater to the vehicle electrical system.

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

The heater interlock release additionally leads to:
- Reset of the fault counter to 0
- Reset of the flame interruption counter to 0
- Reset of the start interruption counter to 0

The heater interlock is recorded by the control device.

4.6 Error output

If the heater is equipped with the standard timer, an error code is displayed on the digital timer after a malfunction occurs, otherwise via flash code given by the operating indicator light.

5 Troubleshooting

5.1 General

This section describes the troubleshooting at the heater Thermo G 300.

ATTENTION:
Troubleshooting may only be performed by briefed and competent trained personnel.

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

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

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

ATTENTION:
Prior to replacing a fuse troubleshooting needs to be performed. The heater must be disconnected from the vehicle electrical system and the fuse is to be replaced when the heater is in currentless state.
A properly dimensioned fuse must be inserted (see chapter 6 Schematic diagrams).
After each error correction a functional test must be performed in the vehicle.

5.2 General error symptoms

The following table lists the possible, general error symptoms.

Table 503 General error symptoms

Error symptom	Possible cause
Error in the electrics	
Operating indication is not illuminated and the heater does not function.	• No voltage supply • Fuse(s) defective • Cable to the pins of plug C of the control device
Fuse F1 triggered	Short circuit or overload of cables and/or heater components Check cables, connectors and components and replace as required.
Fuse F2 triggered.	Short circuit or overload of cables or of the circulating pump Check cables, connectors and components and replace as required.
Fuse F3 triggered	Short circuit in the supply cable to the main switch or, if installed, in the digital timer
Heater is functional, however the operating display is not illuminated	Operating indication defective or cables leading to the operating indication interrupted or shorted

Table 503 General error symptoms

Error symptom	Possible cause
Fehler im Wassersystem Circulating pump failure (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 bottle necks • Circulating pump delivery rate insufficient(air in pump housing) • insufficient frost protection (antifreeze) • System resistance too high (especially high in cold weather) • Circulating pump defective <u>Heat exchanger provides not enough heat, because</u> • Air in the heat exchangers and/or system sections • Contaminated heat exchangers • 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:

$$\text{Flow rate in in [l/h]} = \frac{\text{Heat flow [kW] according to type plate}}{\text{Temperature difference } \Delta t \text{ in [K]}} \times 860$$

Temperature difference Δt in [K]
measured on the heater between water inlet and water outlet
(e.g. using contact thermometer)

Table 503 General error symptoms

Error symptom	Possible cause
Error in the fuel supply	
No fuel supply to the heater	• empty gas tank • bent, closed, clogged or leaky lines • frozen water inlets in the gas regulator or in the gas line • closed gas supply valve • solenoid valve 1 or 2 don‘t open • defective gas pressure regulator
Faults in combustion	
combustion irregularly	• the speed of the combustion air fan is too low • defective combustion air fan • restricted combustion air supply • restricted gas supply • the methane content of the gas doesn’t match requirements (min. 95% by volume) see also Cha. 9: Thermo G Heater with L Gas - Retrofit kit 11149182_ • contaminated protection grid at combustion air intake

5.3 Malfunction code output via flash code

The kind of malfunction is indicated from the operating indication light through a flash code, and if a standard timer is used, on the display (operating indication) respectively.
The flash code is immediately generated after detection of the malfunction and will be kept while the heater is powered on until the heater is freed.
The flash code comprises of a burst (sequence) of 5 short flashes depicting the break and a defined number of long pulses corresponding to the malfunction number, which are to be counted. After that the cycle starts with 5 short flashes again and so on.
The meaning of the number of long pulses is shown in the table below.

Flash code output

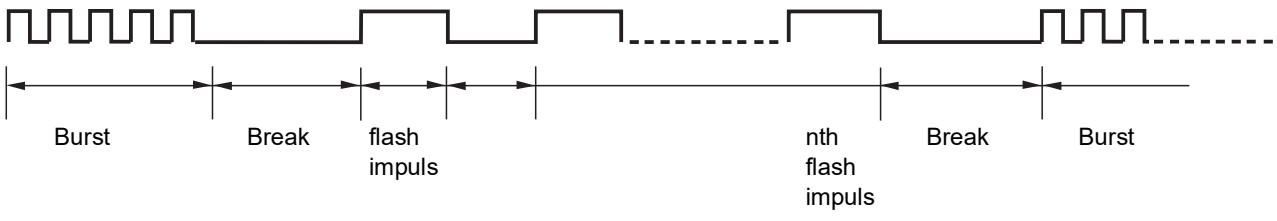


Table 504 : Flash code

No. of impulses	Error	Error description
0	Control device error (is not indicated at timer 1531)	Control device error
1	No start within safety period	No start within safety period (10 sec.)
2	Flame interruption	Flame interruption during burner operation, repeated starts unsuccessful
3	Low Voltage / high voltage	High voltage (> 30V, at least 6 seconds)
		Low voltage (< 20.5V, at least 20 seconds)
4	Extraneous light in initial or purge cycle	Extraneous light in purge cycle 2
		Extraneous light prior to ignition
5	not used	
6	Temperature sensor / overheat protection defective	Temperature sensor short circuit
		Temperature sensor interruption
		Temperature sensor / overheat protection non-plausible
		Overheat protection short circuit
		Overheat protection interruption
7	Solenoid valve 1 or 2 defective	Solenoid valve short circuit
		Solenoid valve interruption
		Solenoid valve doesn‘t close
8	Combustion air fan motor defective	Combustion air fan motor short circuit
9	Circulating pump defective	Circulating pump short circuit
10	Overheat protection triggered	Overheating T>135°C
11	ZF module (ignition unit) defective	Electronic ignition unit short circuit
		Electronic ignition unit interruption
12	Heater interlock	Flame interruption counter threshold exceeded (5)
		Heater interlock - release required
		Malfunction counter threshold exceeded (8)
13	Electrical pressure regulator heating defective	short circuit/interruption

5.4 Error symptoms during functional tests with malfunction code output

5.4.1 Error symptom "No start within safety period"

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

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

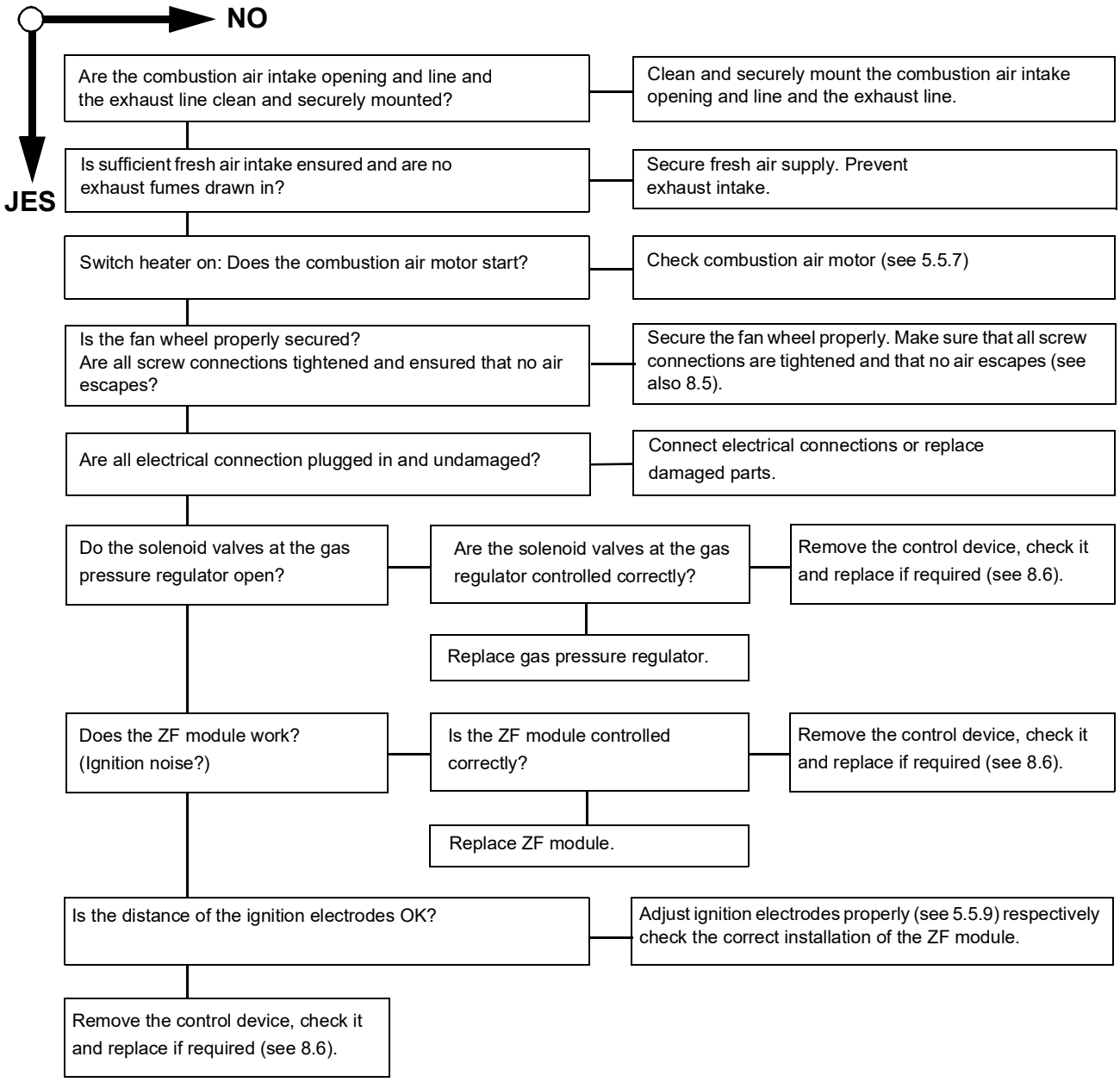
The "No start within safety period" error symptom does not always indicate that no ignition took place.
This symptom occurs as well, if the heater fails to enter heating operation after a successful ignition, e.g. in case the fuel supply is interrupted.

5.4.2 Error symptom "Flame interruption"

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

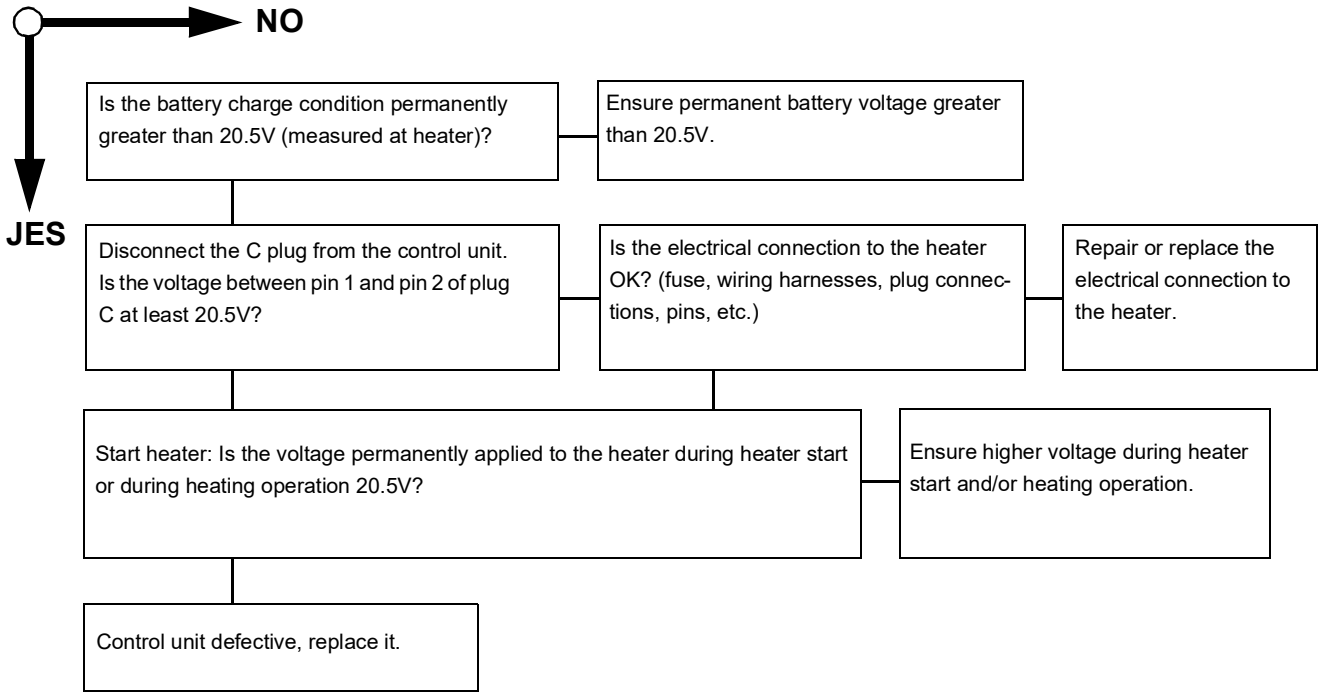
NOTE:
After above mentioned error symptoms occur, troubleshooting according to page 506 is recommended.

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

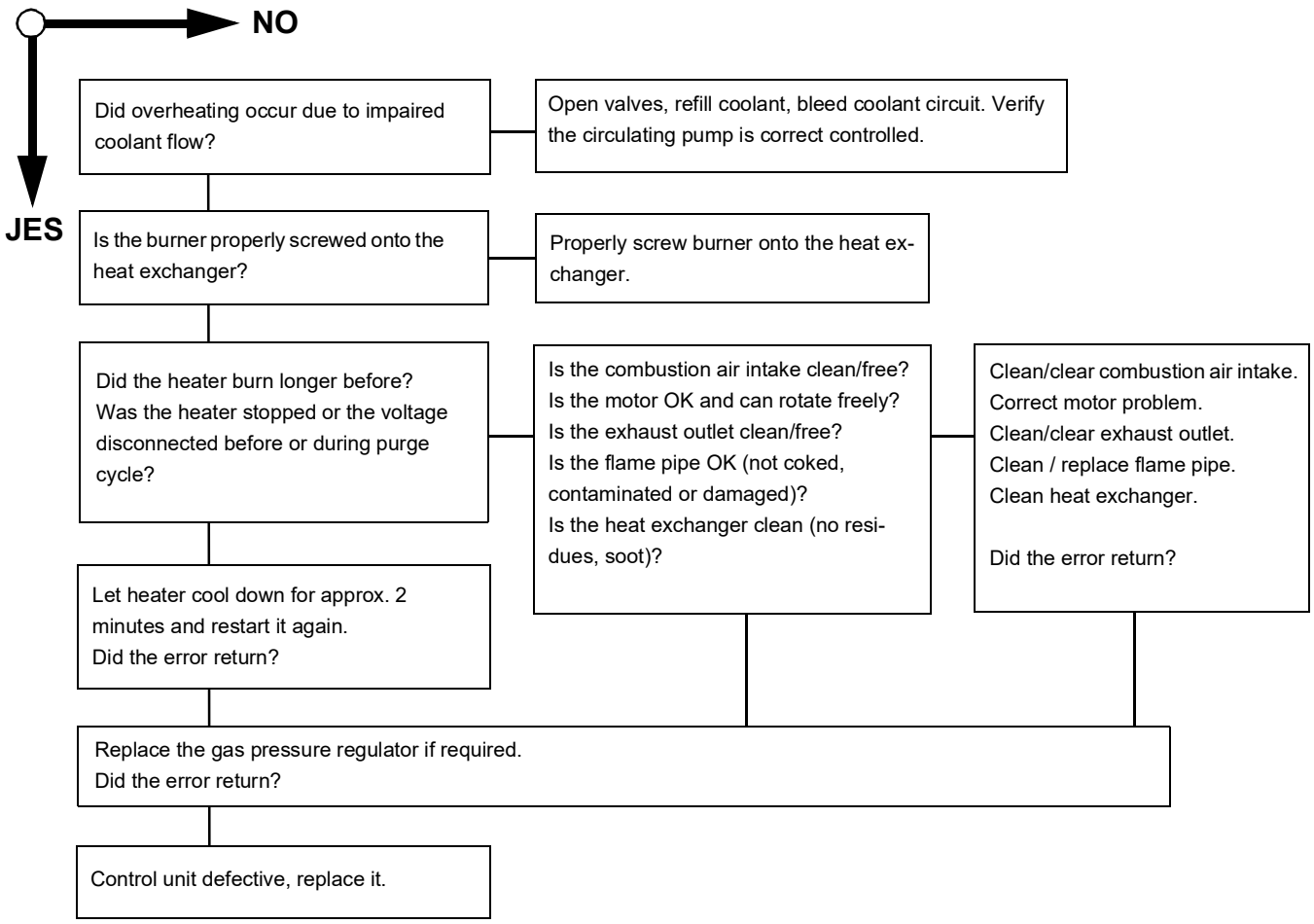

NO
JES
Are the combustion air intake opening and line and the exhaust line clean and securely mounted?
Clean and securely mount the combustion air intake opening and line and the exhaust line.
Is sufficient fresh air intake ensured and are no exhaust fumes drawn in?
Secure fresh air supply. Prevent exhaust intake.
Switch heater on: Does the combustion air motor start?
Check combustion air motor (see 5.5.7)
Is the fan wheel properly secured?
Are all screw connections tightened and ensured that no air escapes?
Secure the fan wheel properly. Make sure that all screw connections are tightened and that no air escapes (see also 8.5).
Are all electrical connection plugged in and undamaged?
Connect electrical connections or replace damaged parts.
Do the solenoid valves at the gas pressure regulator open?
Are the solenoid valves at the gas regulator controlled correctly?
Remove the control device, check it and replace if required (see 8.6).
Replace gas pressure regulator.
Does the ZF module work? (Ignition noise?)
Is the ZF module controlled correctly?
Remove the control device, check it and replace if required (see 8.6).
Replace ZF module.
Is the distance of the ignition electrodes OK?
Adjust ignition electrodes properly (see 5.5.9) respectively check the correct installation of the ZF module.
Remove the control device, check it and replace if required (see 8.6).

5.4.3 Error symptom "Low voltage"

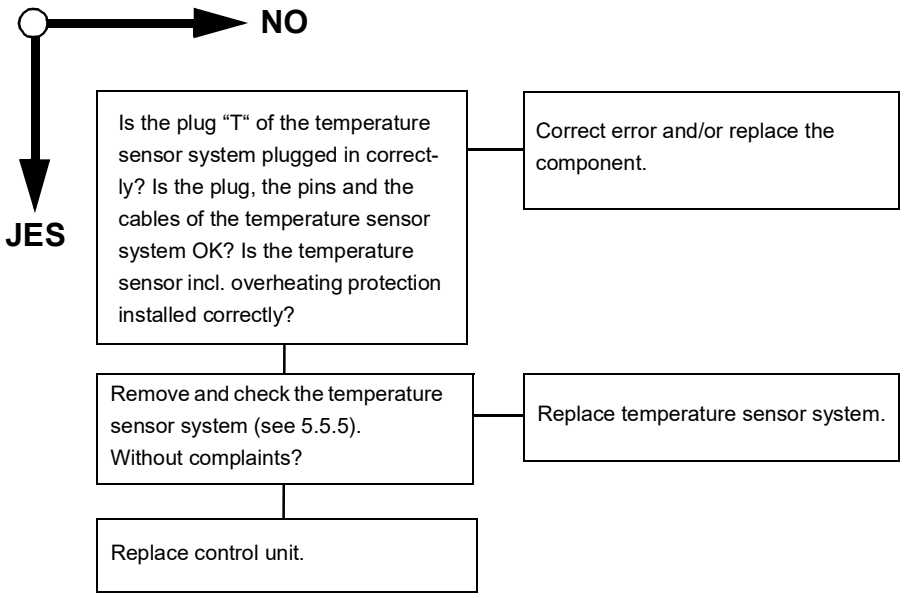
A value is stored in the control unit as smallest "permissible low voltage".
It must be noted that the voltage may be lowered during heater start, and that the "low voltage" threshold may be violated.
Among others this depends on the vehicle electrical system, the temperature of optional components,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



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

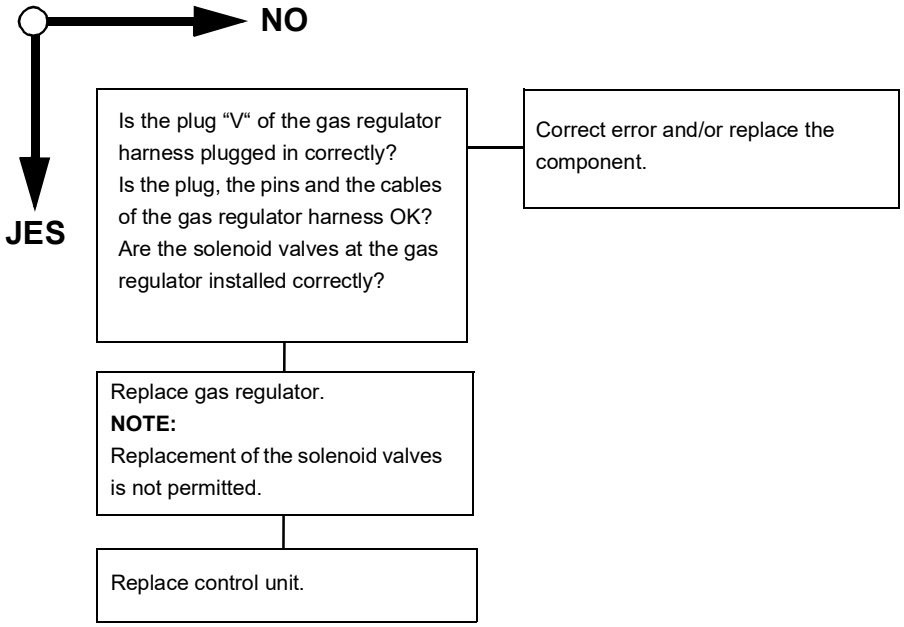


5.4.5 Error symptoms "Temperature sensor / overheating protection defective"

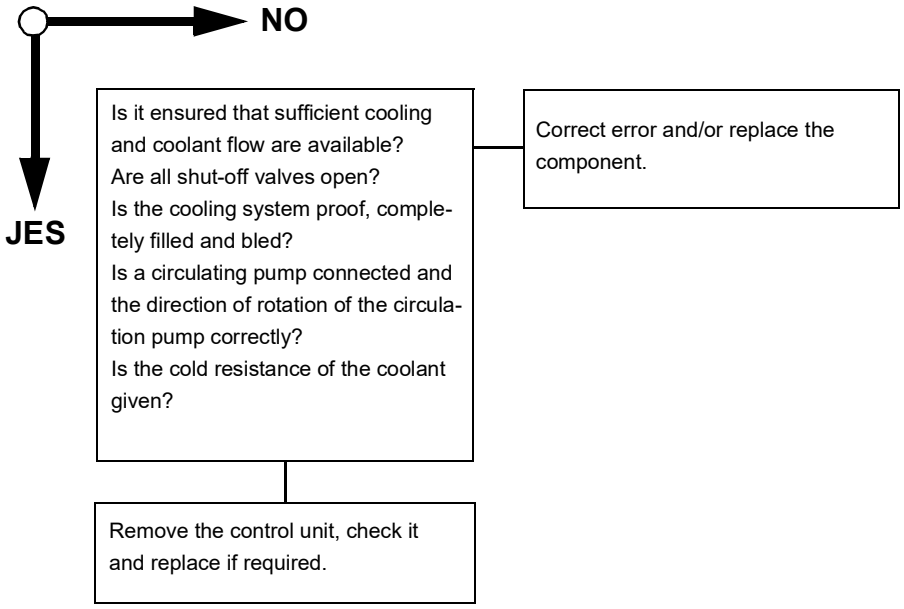


5.4.6 Error symptom "Solenoid valve 1 or 2 defective"

The solenoid valves 1 and 2 are at the gas pressure regulator (see Chapter 3, Section 3.5).



5.4.7 Error symptom "Overheat protection has triggered"



5.5 Individual component tests

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

Warning!	Danger to life and health!

The general safety regulations according to Chapter 1 must be observed.

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

5.5.1 General visual inspection

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

5.5.2 Heat exchanger visual inspection

1. Inspect heat exchanger interior for damage, corrosion, sooting and deposits.
2. 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.

5.5.3 Visual inspection of exhaust outlet and exhaust line

Inspect exhaust outlet and possibly available exhaust line for conditions, tight fit, contamination and deposits.

5.5.4 Combustion chamber visual inspection

1. Remove combustion chamber (see 8.10).
2. Check combustion chamber for scaling and coke deposits and remove them if necessary.
3. Inspect combustion chamber for deformation and moisture.
4. Inspect combustion chamber for cracks.

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

5. After the inspection is completed, reinstall the combustion chamber (see 8.10).

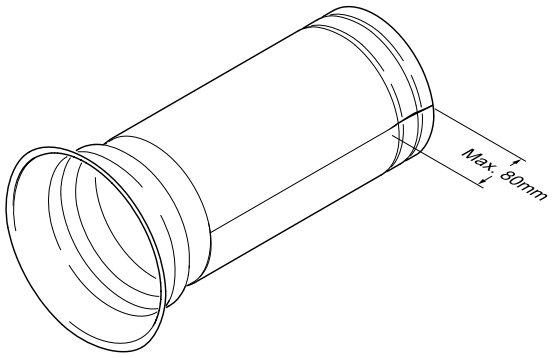


Fig. 501

5.5.5 Resistance check of the temperature sensor with integrated overheat protection

Caution!	Risk of scalds!

Prior to removing the temperature sensor, the overpressure in the cooling system must be released (i.e. by opening the radiator cap). 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

1. Inspect temperature sensor, plug and cable for damage and proper fit.
2. Remove temperature sensor (see 8.2).
3. Perform the electrical test using a measuring device suitable for resistance measurements.
   The electrical resistance between pin 1 and pin 3 (see Fig. 502) is at 0°C 2000 Ohm, between pin 2 and pin 3 500 Ohm. Both resistances change depending on temperature. The ratio should be at tempered through sensor 1:4.
4. Install temperature sensor (see 8.2).

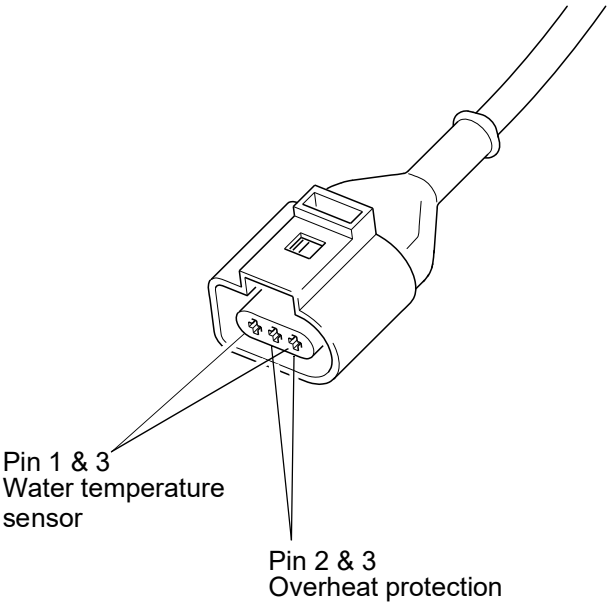


Fig. 502

5.5.6 Fan and combustion air intake line visual inspection

1. Inspect a possibly available combustion air intake line for contamination, condition and deposits.
2. Remove burner head (see 8.4).
3. Separate mixing chamber and fan housing (see 8.5).
4. Remove fan wheel (see 8.8).
5. Inspect fan wheel for damages, the channels of the fan wheel for contamination and deposits.
6. Install fan wheel (see 8.7).
   In the course of this check circlip for proper fit.
7. Check the combustion air fan for smoothness.
8. Install mixing chamber to the fan housing (see 8.5).
9. Install burner head (see 8.4).

5.5.7 Burner motor inspection

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

1. Remove burner head (see 8.4).
2. Separate mixing chamber and fan housing (see 8.5).
3. Inspect the motor for bearing conditions (stiffness).
4. Disconnect motor plug from the control unit.
5. Check motor with 24VDC (Pin 1 to 24V+).
6. Reconnect motor plug to the control unit.
7. Install mixing chamber to the fan housing (see 8.5).
8. Install burner head (see 8.4).

5.5.8 ZF module inspection

NOTE:
It can only be verified by visual inspection of the igni-tion electrode, whether the ignition spark jumps over to the ignition electrode.

Warning!	**Risc of electric shock!**

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.

Check with STT diagnosis adapter

1. Remove burner head (see 8.4).
2. Connect the test plug instead of the temperature sensor plug to the control unit.
3. Reconnect the heater to the vehicle electrical system.
4. Connect the SST diagnosis adapter to the heater and a PC via the interface on the control unit.
5. Start SST diagnosis, establish connection to the heater and open the Component Test menu.
6. Select the ZF module in the Component Test menu, enter a runtime and start the component test.
7. Nominal condition: Ignition sparks at the ignition electrode jump over with a rate of 6Hz.
8. After the test is completed, exit SST diagnosis as needed.

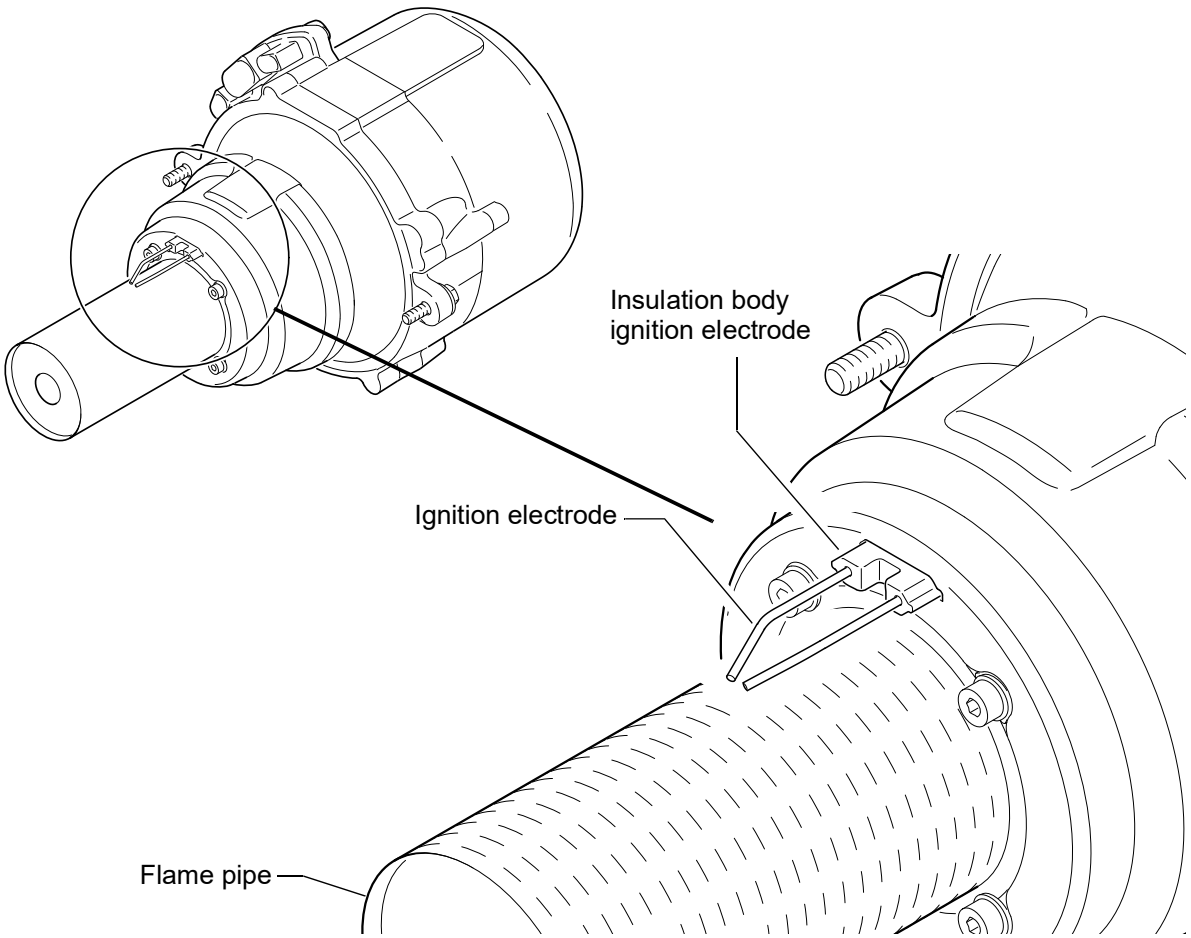


Fig. 503 Burner head - ZF module

9. Disconnect the heater from the vehicle electrical system.
10. Disconnect the test plug.
11. Install burner head (see 8.4).

5.5.9 Ignition electrode inspection

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

1. Remove burner head (see 8.4)
2. Check distance of the electrode tips to the flame pipe (see Fig. 504).
3. Check the distance between the electrodes (see Fig. 505).
4. Inspect the ignition electrode insulation body for damage.

Functionality is verified while inspecting the ZF module.

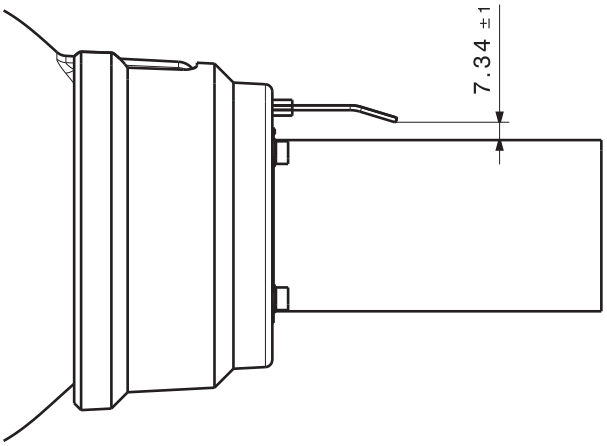


Fig. 504 Distance of the ignition electrodes to the flame pipe

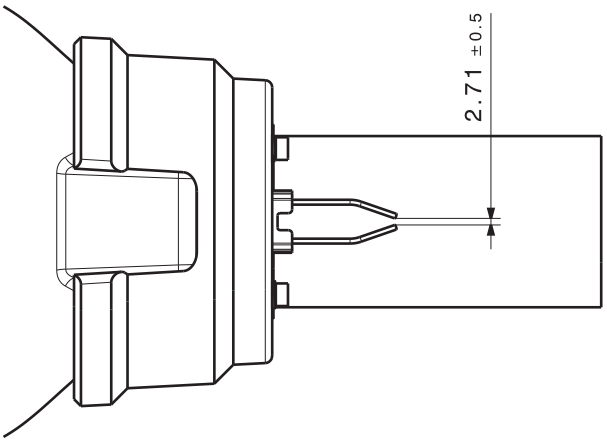


Fig. 505 Distance between ignition electrodes

5.5.10 Heat protection cover inspection

Check the heat protection cover visually. For that remove the burner head (see 8.4).

NOTE:
Cracks and small outbreaks in heat protection cover are permitted and do not constitute a impairment.

The area of the heat protection cover in which outbreaks are permitted is gray marked in Fig. 506.

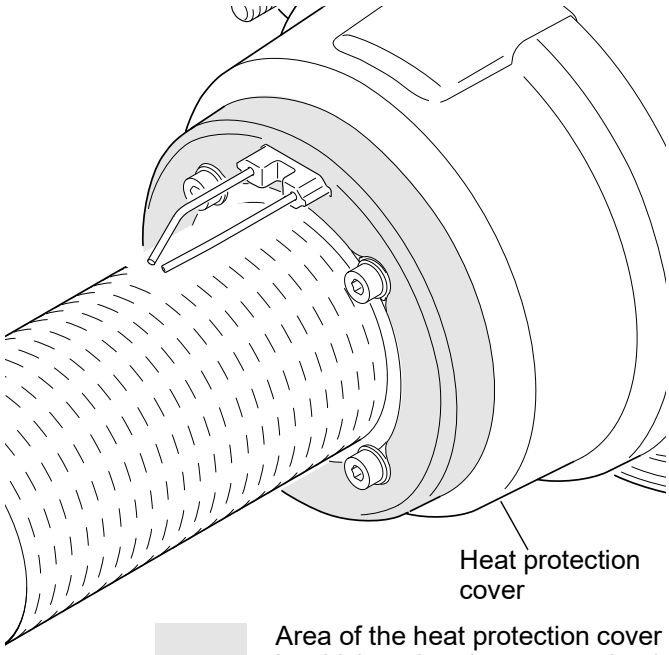


Fig. 506 Outbreaks at the heat protection cover

5.5.11 Gas pressure regulator inspection

ATTENTION:

The gas pressure regulator must not be disassembled.

NOTE:
The check is performed when the gas pressure regulator is installed.

5.5.11.1 General tests

- Check the plug pins for corrosion and tight fit.
- Was the gas pressure regulator replaced after 4 years of operation?
- When the heater is switched off, no gas may escape through the outlet to the heater, even when solenoids are open.
- The supply line connection must be checked for impermeability.

5.5.11.2 Examination of the solenoid valves at the gas pressure regulator

During heater operation disconnect plug connection to the gas pressure regulator.
The combustion must stop immediately. If the combustion

does not stop immediately, the gas regulator must be replaced.

5.5.11.3 Test of the electrical functionality of the solenoid valves at the gas pressure regulator

ATENTION:

The replacement of one or both solenoid valves at the gas pressure regulator is not permitted.
If one or both solenoid valves on the gas regulator does not function correctly, the gas regulator must be replaced.

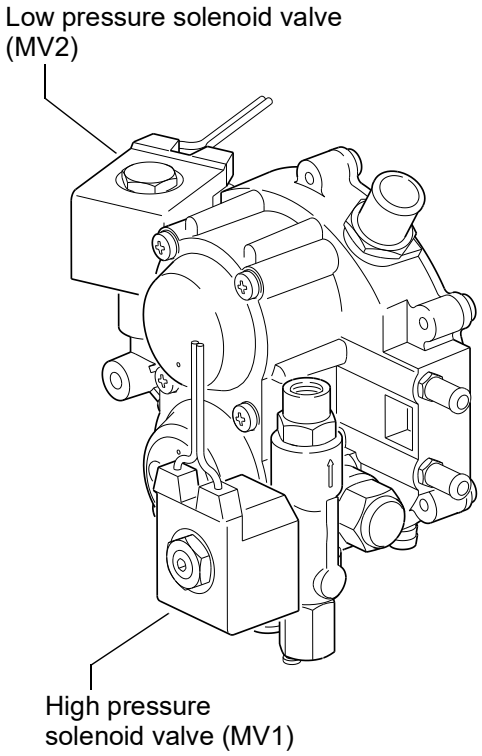


Fig. 507 Solenoid valves at the gas pressure regulator

The electrical function of the solenoid valves can be tested manually.

Manual test:

1. Disconnect the heater from the vehicle electrical system.

2. Shut-off gas supply to the gas pressure regulator.

3. Disconnect plug „V“ from the control unit.

4. Check electrical function by applying 24VDC:
   – Opening voltage: as of 17,0 Volt
   – Power consumption at 24V and 20°C: 24 Watt
   – Rated current at 24V: 1,0 Ampere

   The solenoid valve must open audibly when applying the DC voltage.

5. Reconnect the plug „V“ to the control unit.

5.5.11.4 Testing the safety valve on the gas pressure regulator

If the intake valve is open (MV1) no gas must escape at the safety valve’s hose connection. If gas escapes, the gas pressure regulator must be replaced.

5.5.11.5 Checking for accumulations of oil and condensation in the gas pressure regulator

Possible accumulations of oil and condensate must be drained by unscrewing the drain plug on the gas pressure regulator. If larger amounts have accumulated, testing must be done to establish whether the quarterly draining interval was adhered to. If the result is positive, the interval must be shortened.

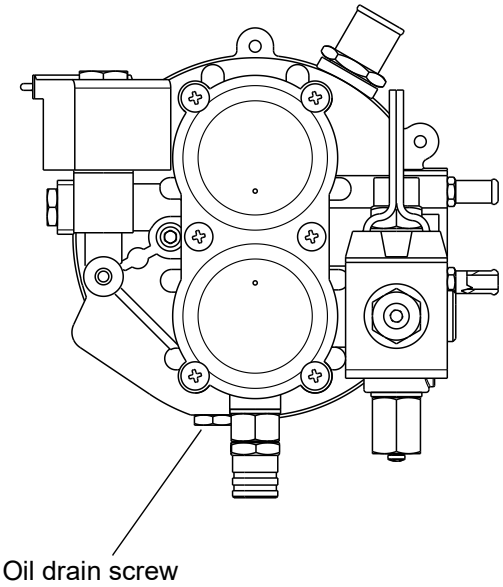


Fig. 508 Oil drain screw at the gas pressure regulator

In the event that solid particulate matter is found in the oil/ condensate, the gas pressure regulator must be replaced. After the test, the drain plug must be screwed in with a tightening torque of 8 ±1 Nm.

6 Wiring diagrams

6.1 General

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

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

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

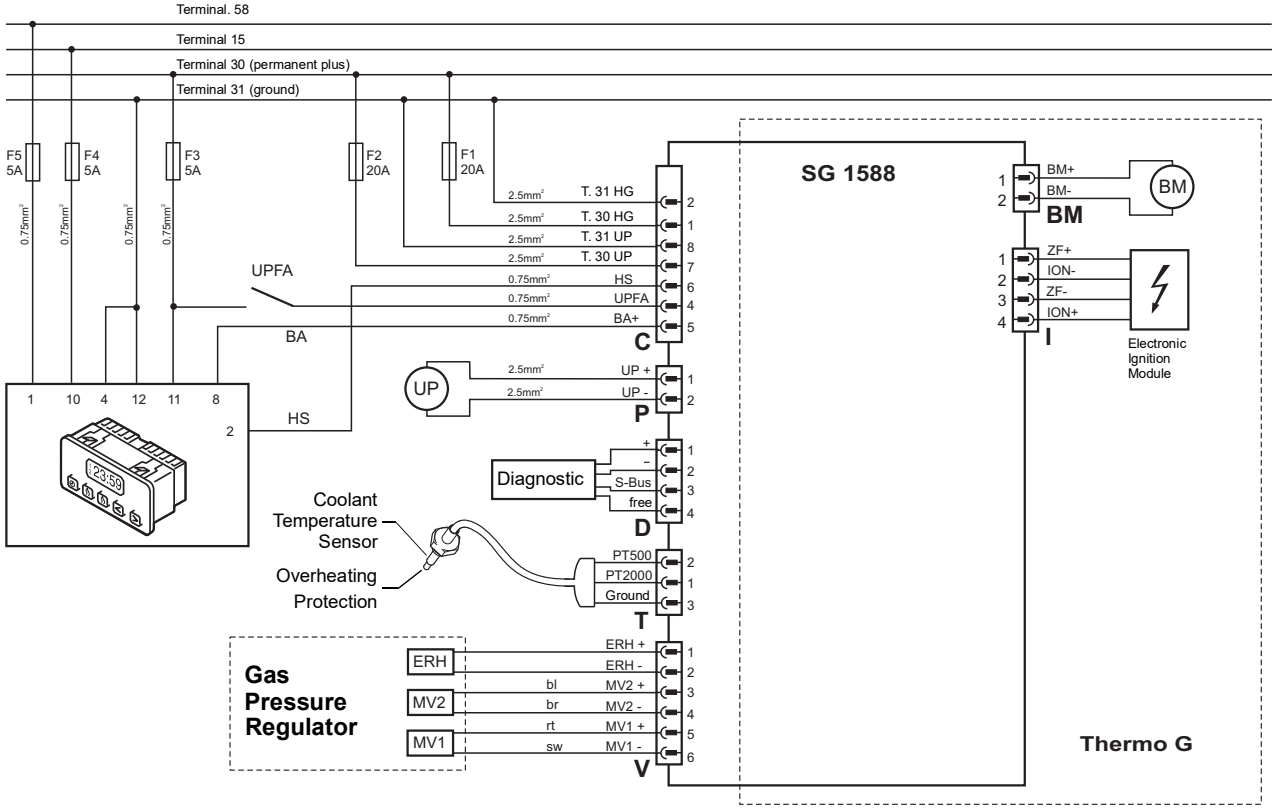


Abb. 601 System wiring diagram for water heaters Thermo G with timer, for legend see page 603

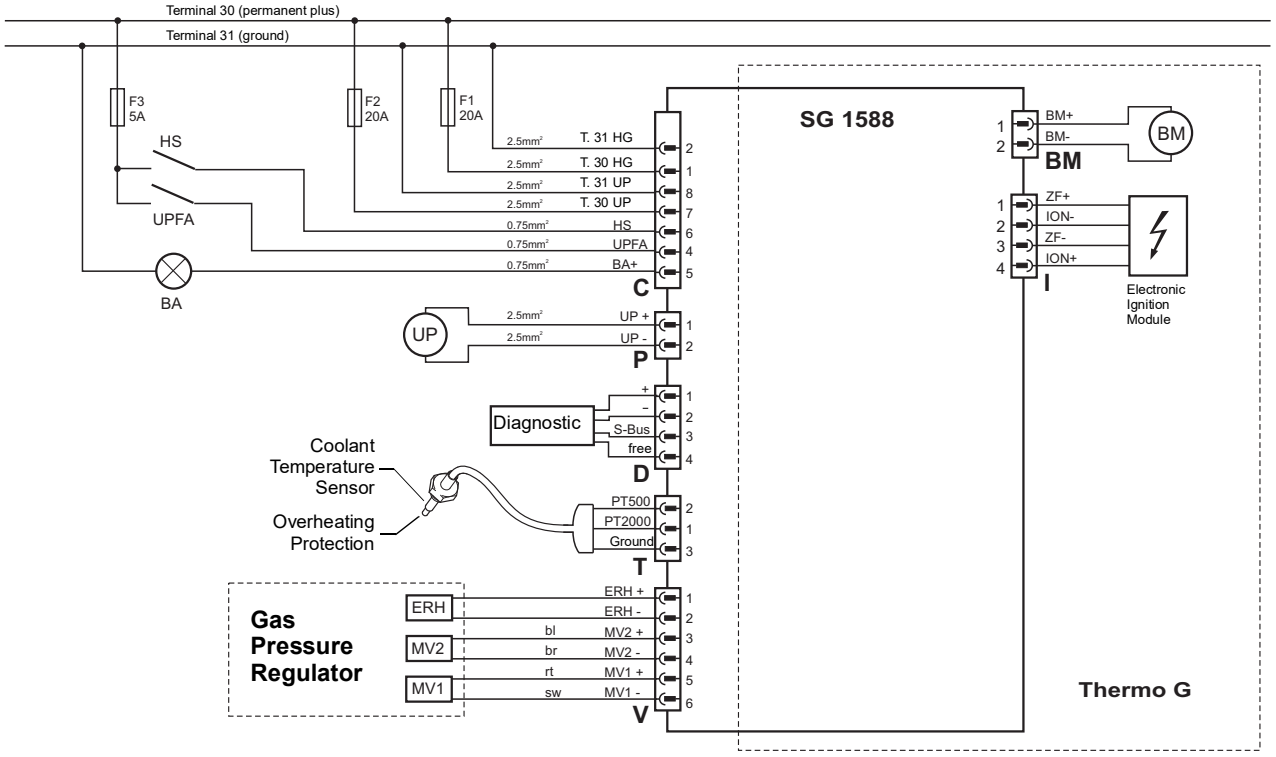
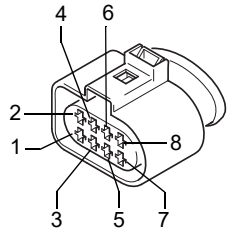
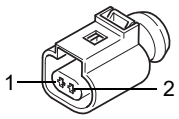
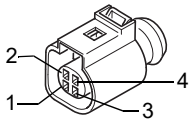
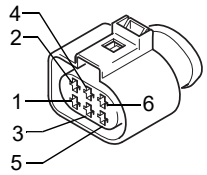


Abb. 602 System wiring diagram for water heaters Thermo G with switch, for legend see page 603

Position	Designation
BA	Operation indicator max. 1x5W or 2x2W
BM	Combustion air motor (in the heater)
ERH	Electrical regulator heating (gas press. regulator)
F1	Car flat-type fuse 20A acc. DIN 72581 part 3
F2	Car flat-type fuse 20A acc. DIN 72581 part 3
F3	Car flat-type fuse 5A acc. DIN 72581 part 3
F4	Car flat-type fuse 5A acc. DIN 72581 part 3
F5	Car flat-type fuse 5A acc. DIN 72581 part 3
HS	Main switch
MV1	High-press. solen. valve, 1st stage (gas regulator)
MV2	Low-press. solen. valve, 2nd stage (gas regulator)
UP	Circulating pump
UPFA	Circulating pump external control
ZF-Modul	Electronic ignition module (in the heater)

Legend for the wiring diagrams

Connector	Description	
C	**To vehicle (Power)**	
C1	Terminal 30 (+)	
C2	Terminal 31 (–)	
C3	--	
C4	UPFA	
C5	Operation indicator +	
C6	Main switch	
C7	Terminal 30 UP	
C8	Terminal 31 UP	
P	**Circulating pump**	
P1	Circulating pump +	
P2	Circulating pump –	
D	**Diagnostic**	
D1	Diagnostic+	
D2	Diagnostic-	
D3	S-Bus	
D4	--	
V	**Solenoid valves and electr. gas regulator heating**	
V1	ERH+	
V2	ERH -	
V3	MV2+	
V4	MV2 -	
V5	MV1+	
V6	MV1 -	

Connector pin assignment

Cable colors	
bl	blue
br	brown
ge	yellow
gn	green
gr	gray
or	orange
rt	red
sw	black
vi	violet
ws	white

7 Servicing

7.1 General

This section describes the work which is permitted to be performed on the heater when it is installed.

Warning!	Danger to life and health!

Work on the heater must only be carried out by trained and / or by Spheros-trained personnel.

Any work on the gas supply line, for example when removing or installing the gas regulator, may only be carried out by persons with the appropriate official authorization.

The heater must be protected against being switched on unintentionally.

NOTE:

When checking for leaks in the gas path it is recommended to use a suitable for gas leak detection spray or a gas detector.
Often into the gas an odorant (fragrance) is mixed, by which a leakage can also be perceived by a distinct odor.

7.2 Heater Servicing

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

When comprehensive repair work is being carried out on the heater, it is advisable to remove it from the vehicle.

After work has been carried out at the heat circuit, a coolant mixture of water and antifreeze must be replenished in accordance with the vehicle manufacturer's instructions and the heating circuit must be bleeded.

7.3 Vehicle Servicing

ATTENTION:

In the vicinity of the heater a temperature of 110 °C must under no circumstances be exceeded (e.g. during paint work on the vehicle).

7.4 Heater test run

Warning!	Risk of Suffocation!

The heater must not be operated, not even with the timer, in enclosed areas like garages or workshops not equipped with exhaust ventilation facilities.

7.5 Servicing

In order to ensure long-term functional reliability, the following maintenance activities should be performed :

- The openings of the protection grid at combustion air intake and the exhaust outlet must be checked for contamination and cleaned as needed.
- Outside the heating season the heater should be operated with the vehicle engine cold approximately every four weeks for 10 minutes setting the heating system to "warm". In this way, starting problems at the beginning of the heating season will be avoided.
- Every three months accumulated oil and condensate must be drained in accordance with 5.5.11.5 at the oil drain plug of the gas pressure regulator.

ATTENTION:

If solid particulate matter is found in the oil/ condensate, the gas pressure regulator must be replaced.

- The gas presure regulator must be replaced every 4 years for safety reasons (ageing of the seals).
- When renewing the coolant for the vehicle's engine, care must be taken to bleed the heater, after the vehicle's cooling system has been bled. Turn on the circulating pump (if there is a separate switch) or turn on the heater for approx. 5 seconds and operate the circulating pump in the purge cycle. This procedure may have to be repeated. Insufficient coolant must be replenished in accordance with the manufacturer's instructions.

NOTE:

The Aquavent 6000C circulating pump has a dry running protection which deactivates the motor in a dry run after approx.10 seconds. The Aquavent 4800SC and 6000SC are shutting down in a dry run only after 45 minutes.
The system is reactivated by disconnecting it from the power supply for approx. 2 minutes.

- At the latest at the beginning of the heating season, the heater and the gas pressure regulator must be tested by a professional.

– Measuring and adjustment of the exhaust CO_2 content as required (see 7.6).

7.6 Measurement and adjustment of the exhaust CO_2 content

The exhaust CO_2 content is to be measured and adjusted as required according to the level given in the technical data under the following circumstances:

– as part of a function check
– in case of combustion irregularities
– after repairs at the burner
– after gas pressure regulator replacement
– after an application customization
– if the heater is operated with CNG (natural gas) which methane content is less than 95 Vol%
– after installation of a replacement burner
– for long-term use at high altitudes

NOTE:
The CO_2 level of the Thermo G 300 replacement burner is adjusted by the manufacturer for use with CNG of class H.

7.6.1 Measurement of the exhaust CO_2 content

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.
In the case no exhaust pipe is connected, for the measurement a flexible pipe of 500 mm length (see accessory catalog) can be used.
At this point also the measurement of the exhaust gas temperature should be performed.
An increased exhaust gas temperature can e.g. indicate a sooted heat exchanger.

1. After a combustion period of approx. 3 min. measure the CO_2 content in the exhaust and compare it to the target value in the Table 201 „Technical data heater“ in Chapter 2.

7.6.2 Adjustment of the exhaust CO_2 content

The exhaust CO_2 content adjustment is performed using an adjustment screw, accessible at the heater above the gas port (see Fig. 701).
By the screw the gas flow rate at the gas inlet and thus the ratio of the gas-air mixture is changed at a given vacuum.

Adjust the exhaust CO_2 content as follows:

1. Check input voltage at the heater.

2. Let the heater run approx. 3 minutes.

3. Measure the CO_2 content in the exhaust and compare it to the target value in the Table 201 „Technical data heater“ in Chapter 2.

4. Insert a hex screw driver into the hole above the gas port (see Fig. 701) and turn the adjustment screw until the target value is reached.

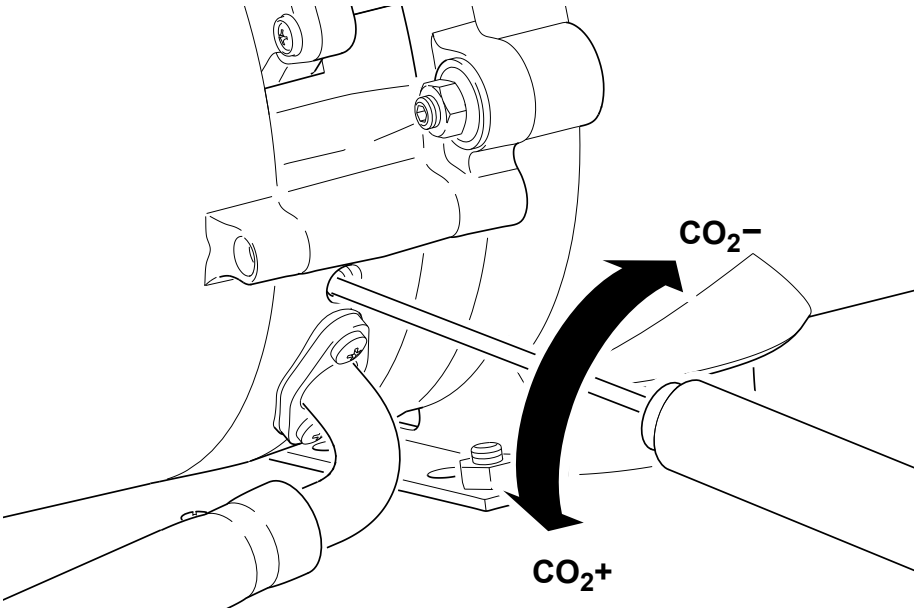


Fig. 701 Adjustment of the exhaust CO_2 content

8 Removal and installation of components and of the heater

8.1 General

Warning!	Danger to life and health!

The general safety regulations according to Chapter 1 must be observed.

Warnung!	Risc of electric shock!

Prior to removing components, disconnect the heater from the vehicle electrical system.

ATTENTION:
Sealing elements between disassembled components must always be replaced.
This does not apply for the gasket ring of the temperature sensor because it is firmly attached.
Screws with thread coating (screw locking) must be replaced.

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

Basically, the access to the individual components of the heater is for the purposes of testing or replacement as follows:

After the removal of the hood, the control device and the fan motor (electric test) are accessible.

By removal of the burner head access to the following components is possible:

- combustion chamber
- flame pipe
- heat exchanger
- ignition electrodes

The separation of the fan housing from the mixing chamber is necessary for the examination or replacement of the following components:

- fan motor
- fan wheel
- ZF-module

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

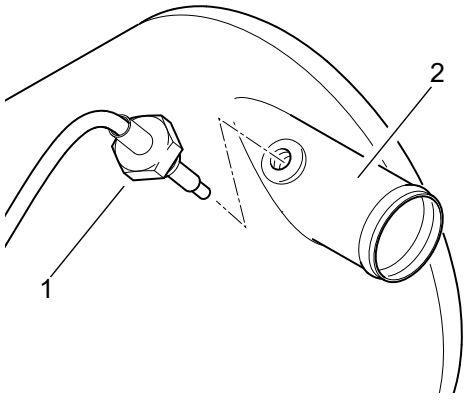
CAUTION!	Risk of scalds!

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

Removal
1. Disconnect the heater from the vehicle electrical system and from the circulating pump as needed.
2. Disconnect the temperature sensor plug (5, Fig. 802).

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

3. Unscrew and remove temperature sensor (1, Fig. 801). Collect the escaping coolant.



1 Temperature sensor
2 Coolant outlet

Fig. 801 temperature sensor removal and installation

Installation
1. Manually screw temperature sensor (1, Fig. 801) into the coolant outlet (2).
2. Tighten temperature sensor (1) with 8 Nm ± 0.5 Nm.
3. Connect temperature sensor plug (5, Fig. 802).
4. Connect the heater with the vehicle electrical system and the circulating pump as needed.

8.3 Hood removal and installation

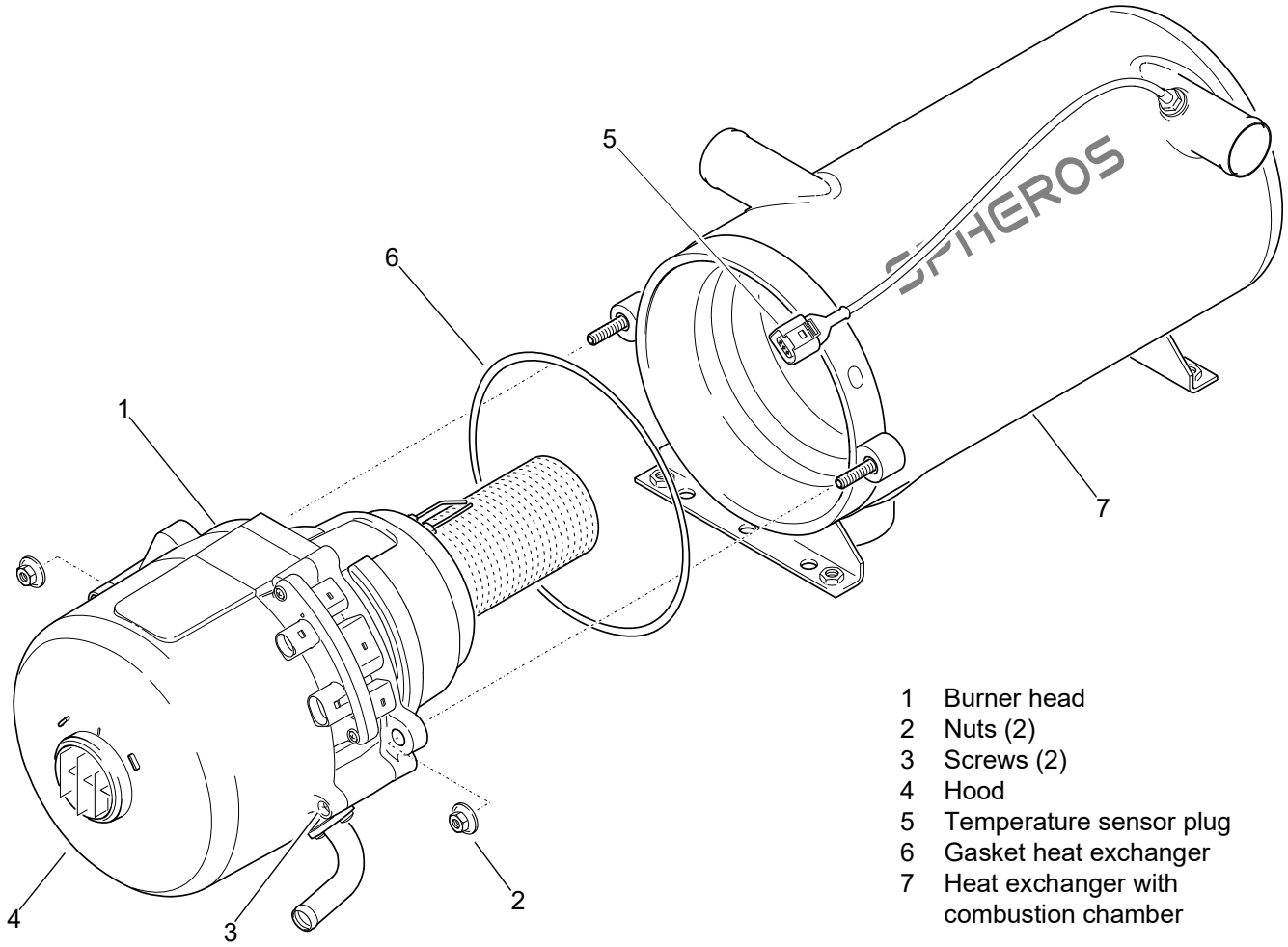
Removal
1. Disconnect the heater from the vehicle electrical system.
2. Loosen screws (3, Fig. 802).
3. Remove hood (4).

Installation
1. Place hood (4, Fig. 802) into installation position. Ensure center alignment and proper fit.
2. Insert screws (3) and tighten with 2 Nm + 0.5 Nm.
3. Connect the heater to the vehicle electrical system.

8.4 Burner head Removal and installation

Burner head removal
1. Disconnect the heater from the vehicle electrical system and from the circulating pump as needed.
2. Disconnect the temperature sensor plug (5, Fig. 802).
3. If necessary, disconnect the combustion air intake line from the heater.
4. Disconnect gas supply hose and seal it with a blank plug.
5. Unscrew nuts (2).
6. Remove burner head (1).

Burner head installation
1. Bring burner head (1, Fig. 802) together with a new gasket ring (6) into assembly position. Ensure center alignment and correct fit of the gasket.
2. Place nuts (2) and alternately tighten them slightly.
3. Tighten nuts (2) with 7.5 + 1 Nm and apply screw locking paint.
4. Remove blank plug from gas supply hose and reconnect gas supply hose to the heater.
5. If necessary, reconnect the combustion air intake line to the heater.
6. Reconnect the temperature sensor plug (5).
7. Connect the heater with the vehicle electrical system and the circulating pump as needed.



1 Burner head
2 Nuts (2)
3 Screws (2)
4 Hood
5 Temperature sensor plug
6 Gasket heat exchanger
7 Heat exchanger with combustion chamber

Fig. 802 Burner head / hood removal and installation

8.5 Separating the fan housing from the mixing chamber

Separating

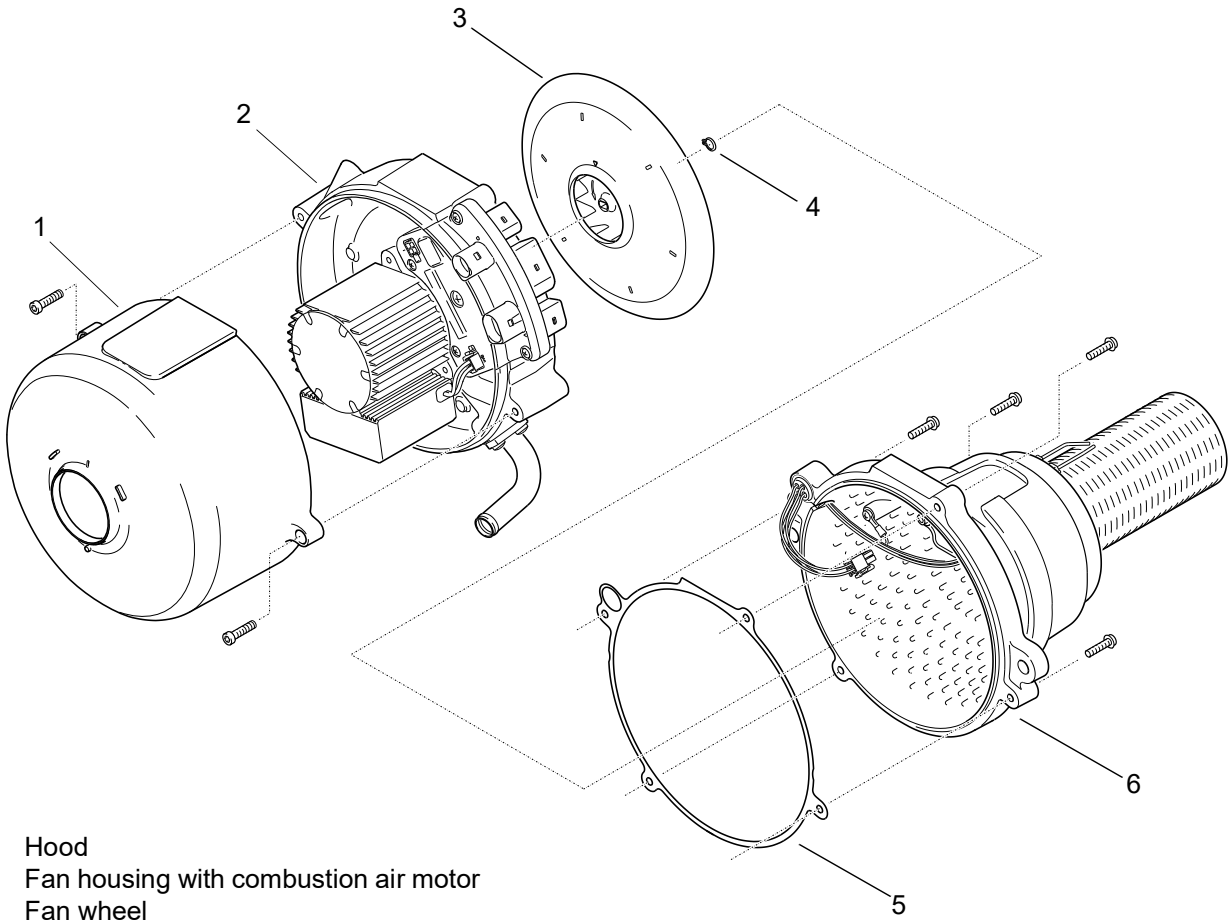
1. Remove burner head (see 8.4).
2. Remove hood (see 8.3).
3. Disconnect ZF-module connector (8, Fig. 804) from control device (5).
4. Remove 4 screws securing the fan housing (2, Fig. 803) to the mixing chamber and remove fan housing (2) carefully together with the with the control device, the fan motor and the fan wheel. During this, the ZF module plug (8, Fig. 804) must be stuck through the hole in the housing.

Assembling

1. Remove any residuals of the mixing chamber seal (5, Fig. 803) from fan housing and/or from the mixing chamber.
2. Bring the the fan housing (2) in assembly position with the mixing chamber (6). During this, ensure the new mixing chamber gasket ring (5) and the ZF module grommet are in the correct position.

ATTENTION:
Before screwing on the fan housing, ensure that the wires of the ZF module and the rubber grommet have the proper position.

3. Attach fan housing (2) to the mixing chamber (6) using 4 screws.
4. Plug the ZF module plug into the control device.
5. Install hood (see 8.3).
6. Install burner head (siee 8.4).



1 Hood
2 Fan housing with combustion air motor
3 Fan wheel
4 Circlip
5 Gasket ring

Fig. 803 Separating the fan housing from the mixing chamber

8.6 Control device removal and Installation

Removal
1. Disconnect the heater from the vehicle electrical system. Disconnect the plug “C“.
2. Disconnect the circulating pump plug “P“.
3. Disconnect the gas pressure regulator plug “V“.
4. Disconnect the temperature sensor plug “T“ (5, Fig. 802).
5. Remove hood (see 8.3).
6. Disconnect the plug of the ZF module (8, Fig. 804) and the fan motor (2) plug from the control device (5).
7. Remove the control device attaching screw (5).
8. Remove the control device (5).

Installation
1. Position control device (5, Fig. 804) to fan housing (3).
2. Screw in the attaching screw of the control device and tighten it (2 +0.5 Nm).
3. Plug the ZF module plug (8) and the fan motor plug (2) into the control device (5).
4. Install hood (see 8.3).
5. Plug in the temperature sensor plug „T“ (5, Fig. 802).
6. Plug in the gas pressure regulator plug „V“.
7. Plug in the circulating pump plug „P“.
8. Plug in „C“ plug.

8.7 Fan wheel removal and installation

Removal
1. Separate the fan housing from the mixing chamber (see 8.5).

ATTENTION:
Do not overstretch the circlip.

2. Remove the fan wheel (4, Fig. 804). For that first remove the shaft circlip (7) using suitable pliers. Then remove the fan wheel.

Installation
1. Remove any residuals of the mixing chamber seal (9, Fig. 804) from fan housing and/or from the mixing chamber.
2. Slide fan wheel (4) onto the motor shaft. Install shaft circlip (7) with suitable pliers.

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

Verify the fan wheel is freely rotatable.
3. Attach fan housing to the mixing chamber (see 8.5).

8.8 Fan motor removal and installation

Removal
1. Separate the fan housing from mixing chamber (see 8.5).

ATTENTION:
Do not overstretch the circlip.

2. Remove the fan wheel (4, Fig. 804). For that first remove the shaft circlip (7) using suitable pliers. Then remove the fan wheel.
3. Remove 3 countersunk screws securing the fan motor (2) to the fan housing (3) and remove the fan motor from fan housing (2).

Installation
1. Position fan motor (2, Fig. 804) onto the fan housing (3) and secure the fan motor (2) using 3 countersunk screws M5x35 (5 +1 Nm).
2. Slide fan wheel (4) onto the motor shaft. Install shaft circlip (7) with suitable pliers.

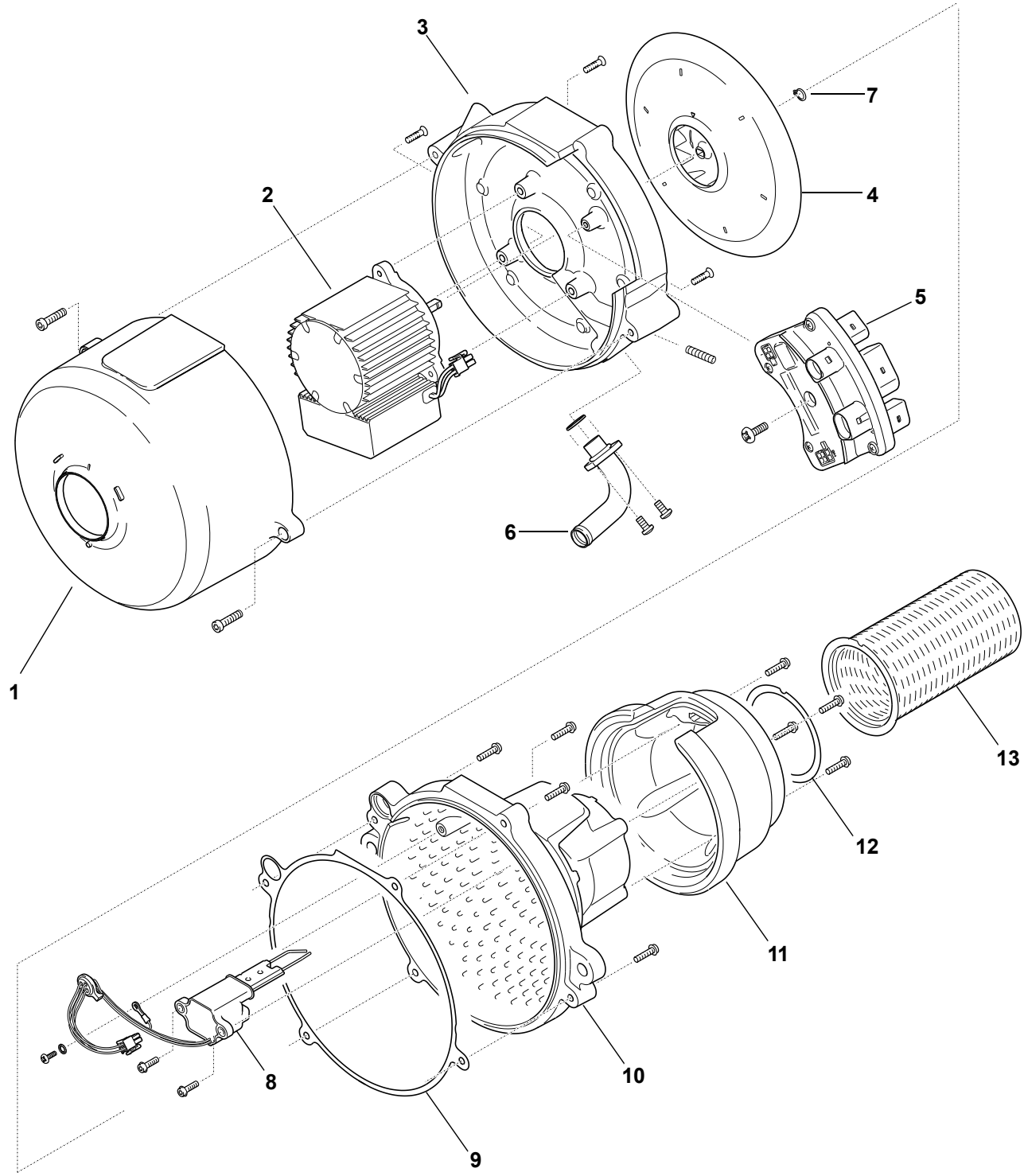
ATTENTION:
Do not use an overstretched shaft circlip! Ensure secure engagement of the circlip in the groove!

Verify the fan wheel is freely rotatable.
3. Attach fan housing to the mixing chamber (see 8.5).

8.9 ZF module removal and installation

Removal
1. Separate the fan housing from the mixing chamber (see 8.5).
2. Remove screw and serrated lock washer, securing the ground cable of the ZF module (8, Fig. 804) to the mixing chamber.
3. Remove screws, securing the ZF module to the mixing chamber and remove the ZF module along with the gasket and the ignition electrodes from the mixing chamber.

Installation
1. Position ZF module (8, Fig. 804) along with the ignition electrodes and gasket into the mixing chamber.
2. Secure ZF module to the mixing chamber using 2 screws.
3. Attach ground cable of the ZF module to the mixing chamber with a screw and a serrated lock washer.
4. Attach fan housing to the mixing chamber (see 8.5).



1 - Hood
2 - Fan motor
3 - Fan housing
4 - Fan wheel
5 - Control device
6 - Gas port
7 - circlip
8 - ZF module
9 - Gasket ring, Mixing chamber
10 - Mixing chamber
11 - Heat protection cover
12 - Gasket, flame pipe
13 - Flame pipe

Fig. 804 Removal and Installation of components

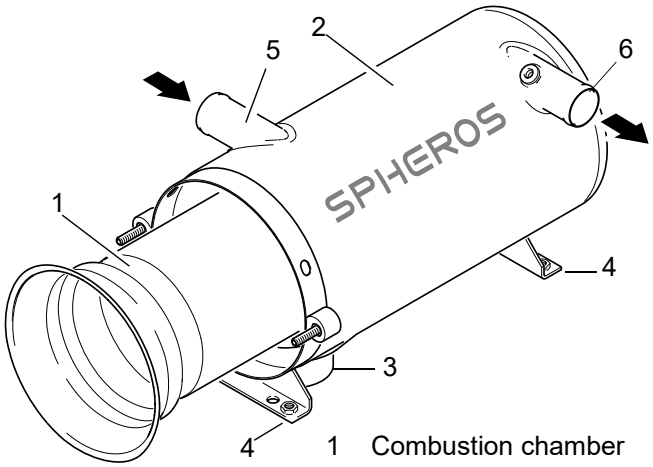
8.10 Combustion chamber removal and installation

Removal

Caution!	Risk of burns!

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

1. Remove burner head (see 8.4).
2. Pull combustion chamber (1, Fig. 805) out of the heat exchanger (2).



1 Combustion chamber
2 Heat exchanger
3 Exhaust outlet
4 Stand
5 Coolant inlet
6 Coolant outlet

Fig. 805 Combustion chamber removal and installation

Installation

1. Slide combustion chamber (1, Fig. 805) until stop into the heat exchanger (2).

HINWEIS:

– **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!). A position change during maintenance is permissible and affects the expected service life of the combustion chamber positively.**

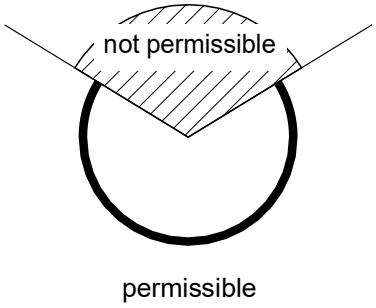


Fig. 806 Combustion chamber welding seam position

2. Install burner head (see 8.4).

8.11 Heat exchanger removal and installation

Caution!	Risk of burns!

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

Removal

1. Remove burner head (see 8.4).
2. If necessary, remove temperature sensor (see 8.2).
3. Pull combustion chamber (1, Fig. 805) out of the heat exchanger (2) (see 8.10).
4. If necessary, loosen the exhaust line clamp on the exhaust outlet (3).
5. If available, close water taps.

Caution!	Risk of scalds!

Prior to disconnecting the coolant houses, the overpressure in the cooling system must be released (i.e. by opening the radiator cap). Observe the risk of injuries due to increased coolant temperature. Possibly let heater additionally cool down and have collecting container ready for discharged coolant.

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.
7. Remove screws and washers at the heat exchanger stand (4).
8. Remove heat exchanger from the vehicle.

Installation

1. Bring the heat exchanger (2, Fig. 805) into installation

position and mount the stand (4) to the vehicle using screws, nuts and washers according to the mounting points used.
2. If necessary, secure the exhaust line using a clamp to the exhaust outlet (3).
3. Fit coolant the hoses onto the coolant inlet (5) and the coolant outlet (6) and secure them with hose clamps applying a tightening torque of 6 ± 0.6 Nm.
4. If available, open the water taps.
5. Install the burner head (see 8.4).
6. Bleed the coolant circuit (see 8.14.1).

8.12 Heater removal and installation

NOTE:
The fuel supply system must be subsequently bleeded (see 8.14.1).

Removal
1. Remove burner head (see 8.4).
2. Remove heat exchanger (see 8.11).

Installation
1. Install heat exchanger (see 8.11)
2. Install burner head (siehe 8.4)
3. Bleed coolant circuit (see 8.14.1).

8.13 Gas pressure regulator removal and installation

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

Work on the gas supply pipe and the gas pressure regulator may only be performed by personnel with an official authorization.

ATTENTION:

Before removing the gas pressure regulator, make sure that the gas supply from the gas reservoir to the gas pressure regulator is shut-off.

Removal
1. Unplug electrical connectors at the gas pressure regulator.
2. Close coolant hoses using pinch-off pliers.

NOTE:
Optionally mark coolant hoses for proper installation.

3. Loosen the hose clamps securing the coolant hoses and remove the hoses.
4. Remove the gas intake line.
5. Loosen the hose clamps securing the gas outlet line and remove the line.
6. Remove the hose from the safety valve.
7. Loosen the nut at the threaded attachment pin and remove the gas pressure regulator together with the washer and spring washer.

Installation
1. Place gas pressure regulator together with the washer and spring washer into installation position and attach it using the nut (tightening torque 20 ±2Nm).
2. Reconnect the hose to the safety valve.
3. Reconnect the gas outlet line and secure it using a hose clamp (tightening torque 5 +0.5Nm).
4. Mount gas intake line (tightening torque 2 +0.5Nm).
5. Reconnect coolant hoses and secure them using hose clamps (tightening torque 1.2 Nm).
6. Remove the pinch-off pliers from the coolant hoses.
7. Restore electrical plug connections.

ATTENTION:

After installation of the gas pressure regulator and before starting the heater the gas intake line connection should be checked for tightness by authorized personnel.

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

During the test run the coolant and fuel connections must be checked for leak-tightness and tight fit.
If the heater goes while operating in an error mode, perform a troubleshooting (see Chapter 5).

8.14.1 Bleeding of the coolant circuit

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

Caution!	**Risk of scalds!**

Risk of scalds at coolant with increased temperature.

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

The Aquavent 5000S (U4854) and Aquavent 6000SC (U4856) circulating pumps may even in dry operation be switched on for bleeding.
Adjust the vehicle heating system to "warm" and refill coolant.
As soon as it is confirmed that the vehicle engine is filled with coolant, run vehicle engine with increased idle speed. Once the cooler thermostat opens, switch the vehicle

engine off and check the coolant level.
Refill coolant as needed.

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

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

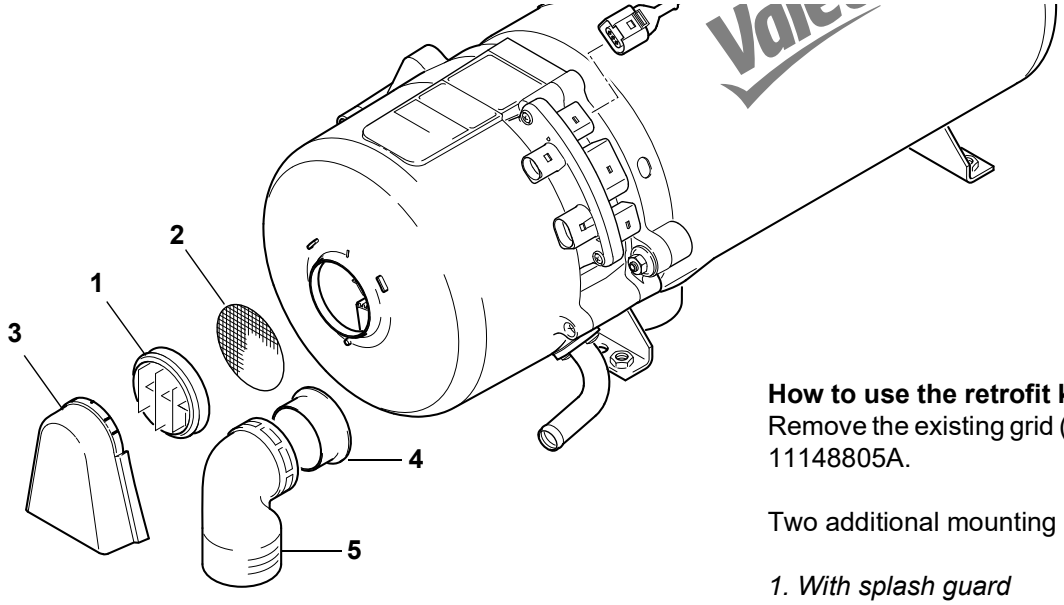
Release the heater (see 4.5) and repeat the bleeding process.

9 Modifications and retrofits

For further optimization the heaters are continuously improved. Units in the field can usually be upgraded or retrofitted. For this purpose respective modification kits will be available. More information can be found in the download center on www.spheros.com.

9.1 Thermo G Heater with L Gas - Retrofit Kit 11149182_

A Thermo G heater can be operated with "H Gas" and "L Gas".
When using L gas, the retrofit kit 11149182A must be used with a modified throughput for combustion air.



Scope of the retrofit kit 11149182_:

Pos.	Qty.	Art. No.	Designation
1	1	20819B	Protection grid
2	1	11148805A	Grid for air intake (if L gas is used)
--	1	11149269A	Mounting instructions

How to use the retrofit kit:
Remove the existing grid (2) and install grid 11148805A.

Two additional mounting variants:

1. With splash guard
Splash guard (3) and grid (2) 11148805A can be used together with L gas. Do not install the protective grid (1).

2. *With elbow 90° for combustion air:*
If the elbow 90° for combustion air (5) is installed with connection (4) and grid (2), its use must be checked separately, as the length of the intake pipe used has an influence on the exhaust gas values.

ATTENTION:
A Thermo G heater can be used with other L gas applications.
If an elbow 90° for combustion air with grid 11148805_ is installed, its use must be checked separately, as the length of the combustion air line used has an influence on the exhaust gas values.

Note:
Natural gas is generally divided into "H" and "L" gas. The general designation criterion "High Caloric" and "Low Caloric" was introduced to better categorize the methane content.
H gas has a methane content of 87 to 98.9% by volume.
L gas has a methane content of 80.1 to 87% by volume.

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 coolant can leak.

Coolant inlet and outlet fittings must be plugged and sealed using blank plugs.

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

Scheduled heater maintenance

The heater should be inspected in scheduled 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 the maintenance
	Vehicle data

Heater data

Type of heater: Ident. no.: Serial no.:	Operating/ control device data acc. diagnosis (SST)	Date of commission

Fuel natural gas (CNG) Class H ☐ Class L ☐

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, 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) Gas pressure regulator: - quaterly drain oil at the oil drain plug	Ensure tight connection of the gas lines! Tighten fittings and hose clamps. After 4 years operation, the gas pressure regulator must be replaced.	☐ ☐	☐ ☐	
c) Check solenoid valves for correct function. For that, during heater operation, disconnect plug connection to the gas pressure regulator. The combustion must stop immediately.		☐	☐	

Check / Maintenance	Important notes	Check result OK.	Check result not OK	Measured values, accomplished repairs
4. Burner Head				
a) Inspect combustion air intake opening for clear passage.		☐	☐	
b) Inspect hood for damage.	Replace damged parts.	☐	☐	
c) Inspect ignition electrodes for damage and correct distance and readjust if required.		☐	☐	
5. Exhaust system				
a) Inspect exhaust line for clear passage, clean or replace it as needed.		☐	☐	
b) Remove combustion chamber from heat exchanger, inspect both parts for damage and contamination, clean and replace as needed.		☐	☐	
c) Insert combustion chamber and mount burner head. Ensure 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.	Secure them with locking compound	☐	☐	
e) Measurements		☐	☐	
Target values and procedures are outlined in the workshop manual	Limits acc. to Regulation ECE-R 122			
Ambient temperature (° C)	see technical data heater	☐	☐	
Exhaust temperature (° C)		☐	☐	
CO_2 (Vol.%)	8,0 ... 9,0 Vol.% at 24V	☐	☐	
Soot level according to Bacharach	≤ 1	☐	☐	
6. Water system				
a) If available, inspect, clean as needed or replace filter insert.		☐	☐	
7. Functional check				
a) Check fault memory, clear it as needed using the diagnosis tool (STT).		☐	☐	
b) Check heater functionality.	after at least 10 min. heater operation	☐	☐	
Attention: During the maintenance, check all screw connections for tightness (for corresponding torque values see Workshop Manual).				

memos

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