HEATING SYSTEMS

Thermo 230
Thermo 300
Thermo 350

with control unit 1572
model .30 and up

Thermo 230
Thermo 300
Thermo 350

with control unit 1572D
model .030 and up

Thermo Rail

Workshop Manual

Rev. 07/2024
Id.No. DOK50088

SPHEROS

Table of contents

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 230, 300 and 350.

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 in the download center of www.spheros.com.

1.3 Meaning of highlighted content

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

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

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

Caution!	**Hazardous to health!**

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

ATTENTION:

This caption points to actions which may cause material damage.

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

1.4 Symbols

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

1.5 Further documentation to be used

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

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

1.6 Safety information and regulations

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

1.6.1 General safety regulations

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

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

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

NOTE:

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

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

1.7 Suggestions for improvement and change

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

service@spheros.com

2 General Description

The water heaters Spheros *Thermo 230, 300* and *350* are used in combination with the vehicle's own heating installation to

– heat the passenger compartment
– preheat water-cooled engines

The water heater operates independent from the vehicle engine and is connected to the vehicle cooling system, the fuel system and the electrical system.

The heater designed to the heat exchanging principle operates intermittently controlled by the temperature sensor.

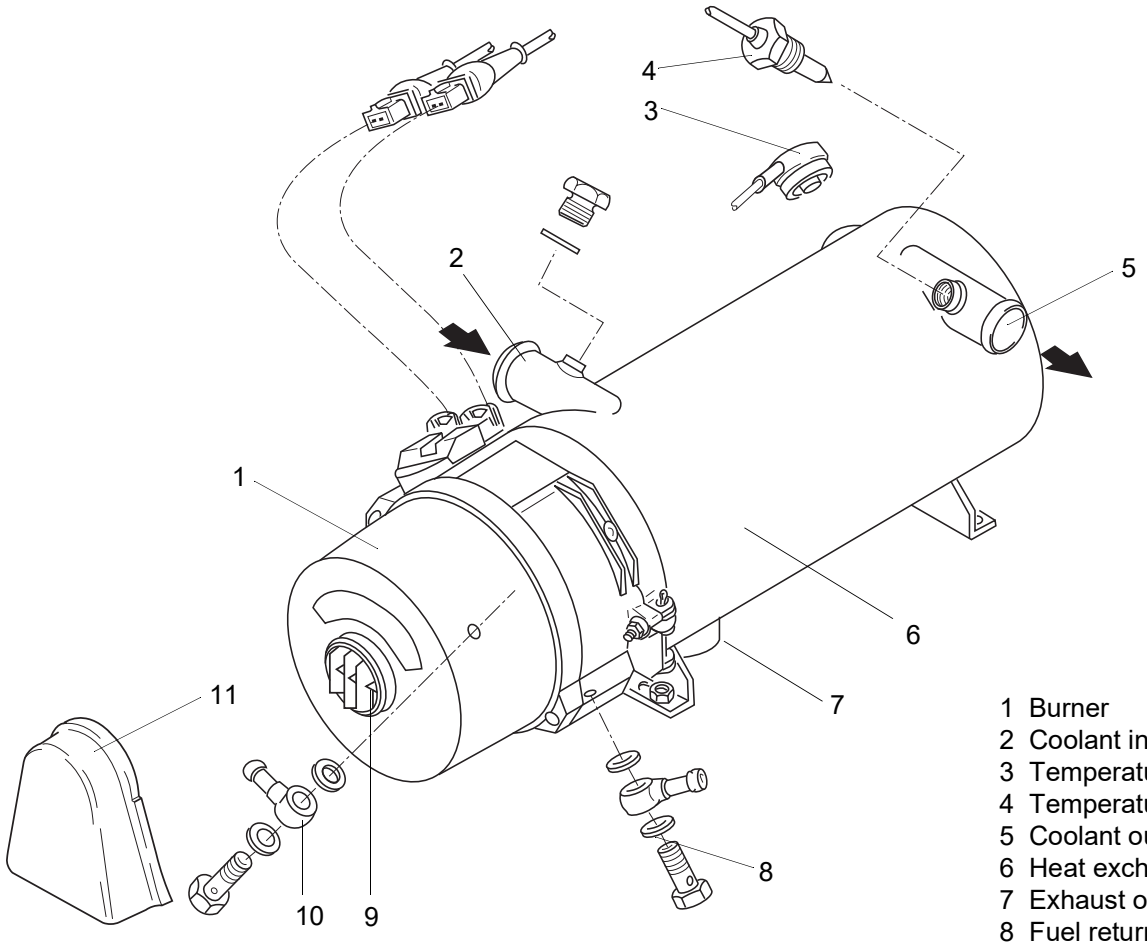
The heaters *Thermo 230, 300* and *350* basically consist of

– the combustion air fan
– the fuel pump with nozzle block and nozzle
– the heat exchanger and
– the combustion chamber
– the igniter box with igniter electrodes

For control and monitoring the heater includes

– a control unit
– a flame sensor
– a temperature sensor
– a temperature limiter
– a temperature limiter without reset button for *the Rail variant .126.*

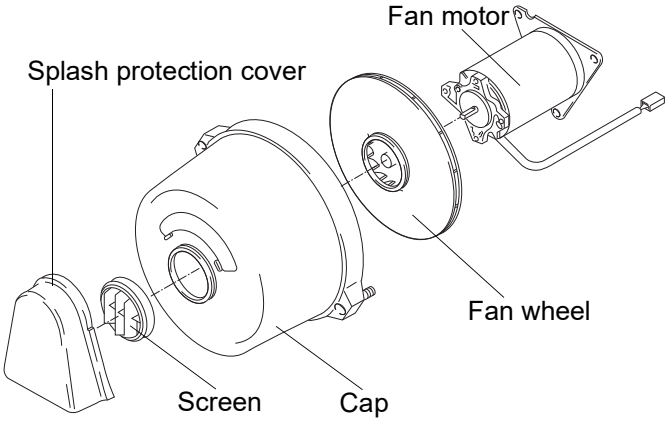
An external circulating pump is installed inside the vehicle, or, in the case of compact units, directly at the heater.



1 Burner
2 Coolant inlet
3 Temperature limiter
4 Temperature sensor
5 Coolant outlet
6 Heat exchanger
7 Exhaust outlet
8 Fuel return
9 Combustion air inlet
10 Fuel delivery
11 Splash protection cover (instead of screen)

2.1 Combustion Air Fan

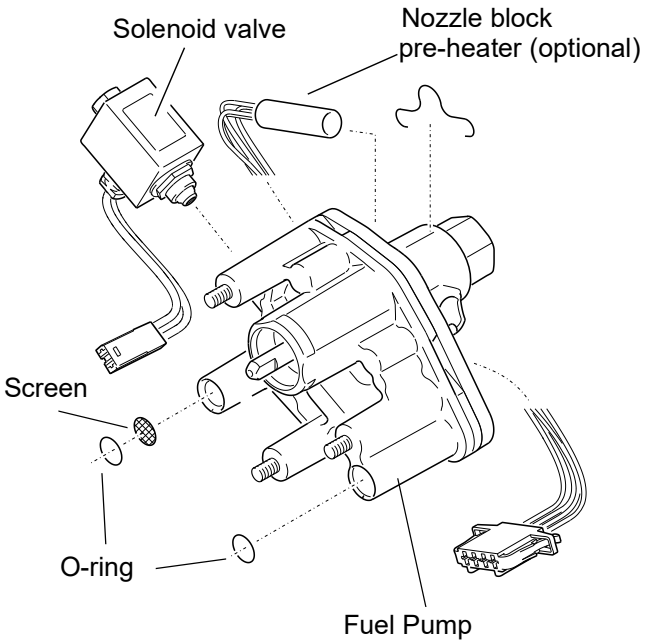
The combustion air fan supplies the air required for combustion from the combustion air inlet to the combus-

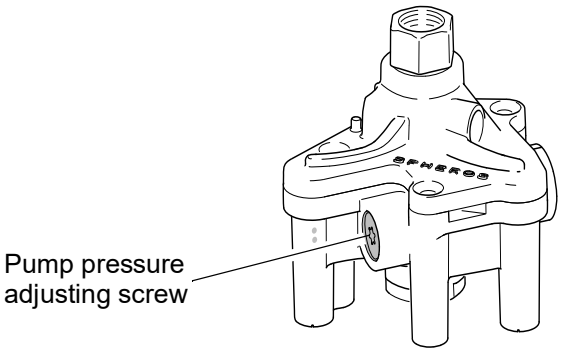


The fan consists of a fan motor with fan wheel. Air is taken in through a splash protection cover or a screen and the cap. The heaters *Thermo 231 and 301* are provided with a splash protection cover only.

2.2 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.
One and the same fuel pump model is assigned to the different heating capacity classes of the Thermo series.





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.

2.2.1 Nozzle block preheater

At extremely low temperatures malfunctions may occur without a nozzle block preheater.
At a temperature of < 0°C a thermostat activates the heater cartridge in the nozzle block. The heating period depends on the heat reflected within the combustion chamber. Preheating is deactivated when the thermostat ambient temperature is +8°C.

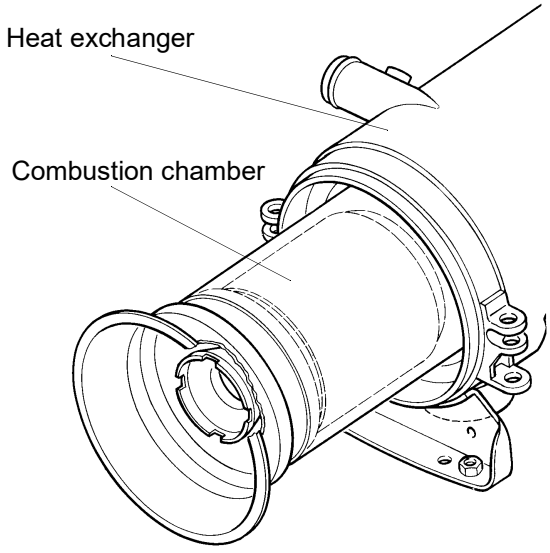
If the heater is not equipped with a nozzle block preheater a retrofit is possible.

2.3 Heat Exchanger

IThe heat exchanger transfers the heat generated by com-bustion to the coolant circuit.

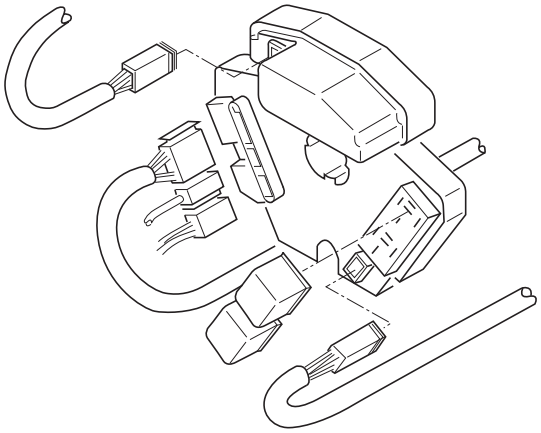
2.4 Combustion Chamber

The fuel/air mix is dispersed in the combustion chamber for combustion to heat the heat exchanger.

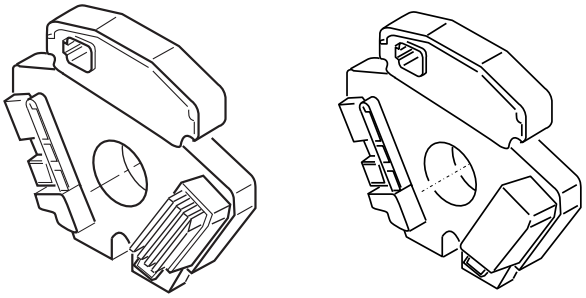


2.5 Control Unit

The control unit 1572 or 1572D is the central component to ensure controlled operation and monitoring of combustion. If the heater has a control unit 1572 installed, a retrofit of control unit 1572D is possible (see Section 9).



Control Unit 1572

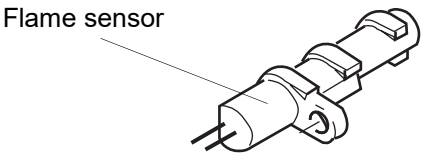


New version from 1.07.24
with integrated flame guard

Control Unit 1572D

2.6 Flame Sensor

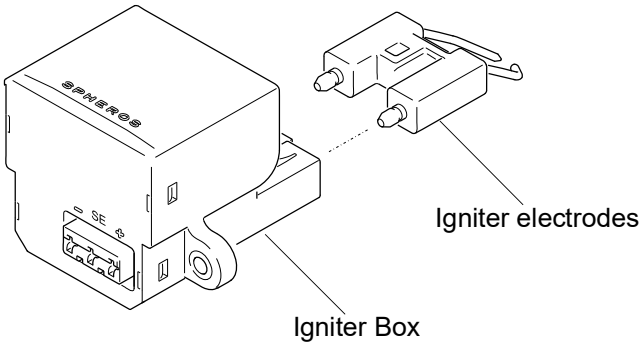
The flame sensor continuously monitors the flame condition during operation. The flame sensor is a photo transistor changing its resistance depending on the flame intensity. The signals are supplied to the control unit for processing.



NOTE:
This flame guard is only installed in heaters manufactured before July 2024. After that, the flame guard is integrated into the control unit.

2.7 Igniter Box with Igniter Electrodes

The igniter box generates the high voltage for igniting the fuel/air mix by a high voltage ignition spark across the electrodes.

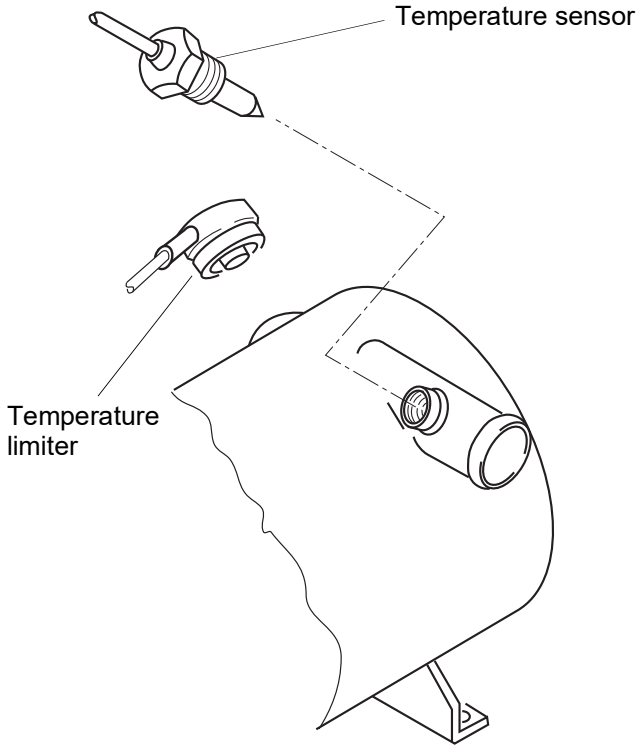


2.8 Temperature Sensor

The temperature sensor senses the coolant temperature at the heat exchanger outlet as an electrical resistance. This signal is supplied to the control unit for processing.

2.9 Temperature Limiter

The temperature limiter (bimetal) protects the heater against undue high operating temperatures.
The temperature limiter responds at a temperature of 125°C and switches off the heater.
In the case of the Rail variant .126, the temperature limiter will reset automatically after down cooling at a temperature below 105°C.
For all other heater variants of the Thermo series, the temperature limiter must be reset manually.



2.10 Circulation Pump

The externally mounted circulation pump ensures proper coolant circulation in the vehicle and heater circuit. 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.
The heaters can be operated with the circulation pumps Aquavent 5000 (U4814), Aquavent 5000S (U4854), Aquavent 6000C (U4855) or Aquavent 6000SC (U4856).

Circulating pump	Delivery rate l/h	Rated voltage V =	Operating voltage range V =	Rated 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 circulating pump fuse may never be pulled, while the pump is running, and may not be replaced, when the pump is switched on.

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

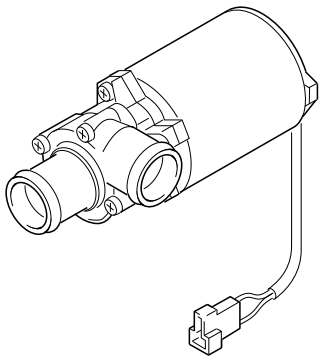
The Aquavent 5000 (U4814) and 5000S (U4854) circulating pumps are equipped with a brush motor.

NOTE
Aquavent 5000 (U4814) with floating-ring type shaft seal.
Aquavent 5000S (U4854) uncoupled by a magnet (no seal).

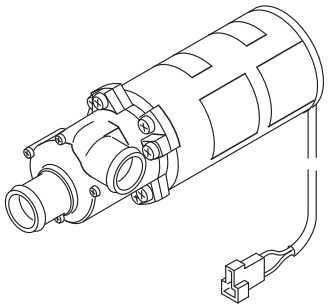
ATTENTION
The circulating pump motor **is not equipped with an internal inverse-polarity protection.**

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

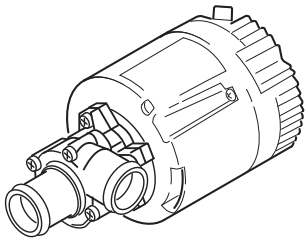
The Aquavent 6000C (U4855) andAquavent 6000SC



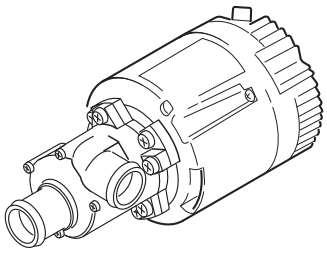
Aquavent 5000
(U4814)



Aquavent 5000S
(U4854)



Aquavent 6000C
(U4855)



Aquavent 6000SC
(U4856)

(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.

Fehlermodus
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.**

2.11 Fuel Filter

At compact devices of the series *230/300/350.126* and *.190 Rail* an optional heatable fuel filter is provided, as an additional option also for *.124* and *.155 Rail*.
If the electrical filter heating is hooked-up, the temperature switch turns the integrated filter heating
on at ≤ 0.5 ± 2.5 °C and
off at ≥ 5.5 ± 2.5 °C fuel temperature.

3 Functional Description

Activation and deactivation is by means of a
- switch
- timer
- air conditioning

dependent on the type of installation.

For monitoring operation at least an operating indicator light is provided.
Switch off releases a run-down procedure (see "Switch off").

The heaters may be
- operated with power save for reduced fuel consumption (see circuit diagram)
- equipped or retrofitted with a nozzle block preheater for extreme low temperatures.

Heaters with control unit 1572D only
When connecting terminal +61 the heaters may operate in the auxiliary heating mode of operation.

Switching thresholds

Control device	**Ident. No. 97821_ before 63482_ Ident. No. 97806_ Bus**	**Ident. No. 97810_ Rail Standard**	**Ident. No. 63859_ Rail J.E.S**
Auxiliary heating			
Upper operating point	85°C	85°C	85°C
Lower operating point	78°C	70°C	75°C

Parking heating			
Upper operating point	85°C	60°C	85°C
Lower operating point	70°C	45°C	70°C

Parking heating (economic setting)			
Upper operating point	70°C	20°C	50°C
Lower operating point	55°C	5°C	40°C

Gradient evaluation	Yes	Yes	Yes
Hysteresis adaption (auxiliary heating only)	Yes	Yes	Yes

Switching thresholds for Thermo xxx Raill

Version Thermo xxx*	**230.040 „VOSSLOH “**	**230.056 350.056 „VOSSLOH “**	**300.124**	**xxx.126**	**300.155 350.155**	**350.190**
Scope of delivery		973 13A thru 973 13D			90 162 37x 90 162 36A 90 162 35A	90 210 12B
Heater						
Control device	638 59_	679 81_		97810_		97812_

Auxiliary heating				
Upper operating point	85°C	80°C	85°C	85°C
Lower operating point	75°C	72°C	70°C	70°C

Parking heating			Preheating	
Upper operating point	85°C	75°C	60°C	60°C
Lower operating point	70°C	60°C	45°C	45°C

Parking heating (economic setting)			keeping frost-free	
Upper operating point	50°C	57°C	20°C	40°C
Lower operating point	40°C	42°C	5°C	25°C

Gradient evaluation	Yes	Yes	Yes	
Hysteresis adaption	Yes	Yes	Yes	

Low voltage threshold				18.5V (20 sec.)

* xxx means 230 or 300 or 350

3.1 Switch On

Upon switch on the operating indicator light goes on. Combustion air fan, fuel pump and circulation pump start operation. (If fitted and temperature is < 0 °C nozzle block preheater is also activated).

After approximately 12 seconds (run-up time) the high voltage igniter spark is available. Approximately 1 second later the solenoid valve in the fuel pump opens and the nozzle sprays fuel into the combustion chamber to be ignited by the igniter spark. A photo control circuit deactivates the igniter box after flame-up.

3.2 Heating Operation

After reaching operating temperature the control unit takes over to provide controlled operation by activation and deactivation of the burner in order to maintain a nearly constant temperature of the heat exchanger (coolant).

The heating operation is terminated as soon as the upper operating point is exceeded.
The heater now is in the control idle period. Heater operation is resumed when the temperature drops below the lower operating point.

Heaters with control unit 1572D only
Gradient evaluation
In case of low coolant flow or poor coolant circuit venting the temperature quickly increases in heating operation. If gradient evaluation exists, the control unit recognises the quick temperature increase and automatically sets the upper switching threshold to a lower value. This prevents residual heat triggering the overheating protection.

Control idle period
A rise in temperature above the upper switching point makes the solenoid valve in the fuel pump shut off the fuel supply initiating the run-down. The flame extinguishes, the combustion air fan and the circulation pump however continue their operation. After approximately 90 seconds (120 seconds for heaters with control unit 1572D) run-down is completed with deactivation of the combustion air fan.

The circulation pump remains in operation during the control idle period. The operating indicator light is on.

3.3 Switch Off

Switching off the heater stops combustion. The operating indicator light goes out and run-down commences. The combustion air fan and circulation pump are deactivated after approximately 90 to 120 seconds (120 seconds for heaters with control unit 1572D).

Reactivation of the heater during run-down is permitted. The burner immediately resumes operation after the run-up time.

3.4 Power Save

With power save on the control temperatures of the heating circuit are kept low. Combustion performance is not reduced.

This results in a reduced heat radiation loss when limited heating performance is required (e.g. in heat hold operation) cutting down fuel consumption.

3.5 Auxiliary Heating Operation (heaters with control unit 1572D only)

When terminal +61 is connected and powered (engine is running), the heater operates in the auxiliary heating mode.
The power save mode is during auxiliary heating automatically deactivated by the control device.

The lower temperature threshold for reactivation of the burner after control idle period is raised above that for normal operation and is automatically shifted up or down dependent on the combustion time of the heater (hysteresis adaptation).

Hysteresis adaptation (example)
After the first control idle period, the lower operating point is 78°C.
Combustion operation is started when the temperature falls below this threshold.
The length of combustion time until the upper operating point is exceeded should be 120 seconds.
If combustion lasts more than 120 seconds, the lower operating point is increased by 1 Kelvin, up to max. 80°C.
If combustion time is less than 120 seconds, the lower operating point is lowered by 1 Kelvin, down to minimally 70°C.

3.6 Heater Lockout (heaters with control unit 1572D only)

After the heater has performed eight start attempts due to a malfunction or after five subsequent flame-outs the heater enters a lockout and start attempts are suspended. This lockout is superior to the normal error lockout. Unlocking is performed by starting the heater and disconnection of the main power supply of the heater during error run-down.

3.7 Switch-off upon Failure (heaters with control unit 1572)

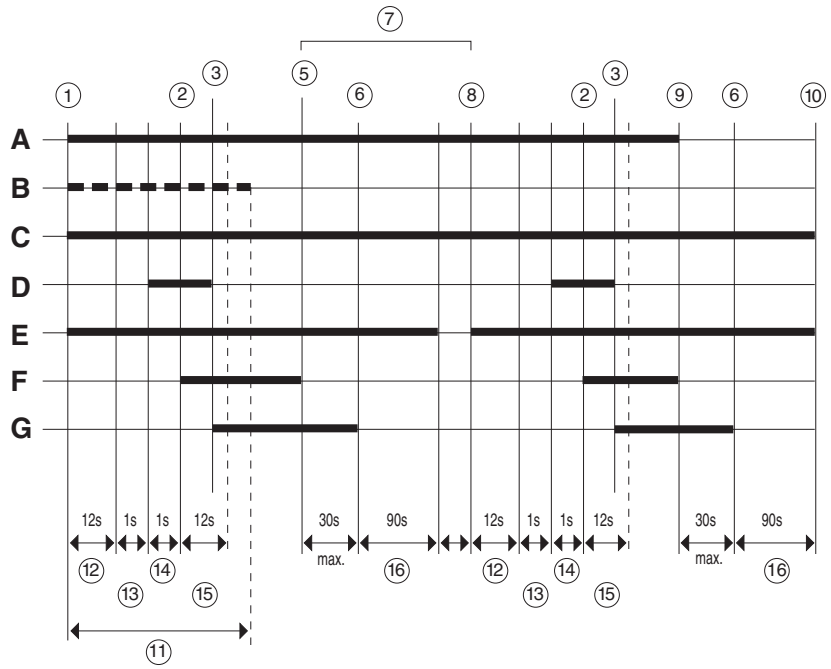
The heater switches off automatically when detecting one of the following malfunctions.

The operating indicator light goes off. Combustion air fan and circulation pump are deactivated after approximately 90 to 120 seconds.

Malfunctions during switch-on
– short or open circuit of temperature sensor.
– short or open circuit of flame sensor / integrated flame sensor.
– open circuit of solenoid valve.

Malfunctions during start-up:
– flame detected by photo control circuit prior to high voltage igniter spark.
– no flame detected after approximately 25 seconds after heater start.

Malfunctions during heating operation:
– low voltage threshold of approximately 20V violated for a duration of 12 seconds.



A	H1	Operating indicator light
B	E1	Heater cartridge
C	M2	Circulation pump
D	U1	Igniter box
E	M1	Combustion air fan
F	Y1	Solenoid valve
G	B1	Flame sensor

1	Switch on
2	Start
3	Combustion operation
5	Temperature sensor – upper switching threshold
6	Flame sensor – dark
7	Control idle
8	Temperature sensor – lower switching threshold
9	Switch off
10	Heater – off
11	Nozzle block preheater
12	Start-up
13	Foreign light check
14	Pre-ignition
15	Safety period
16	Run-down

Fig. 301:Functional sequence (heaters with control unit 1572)

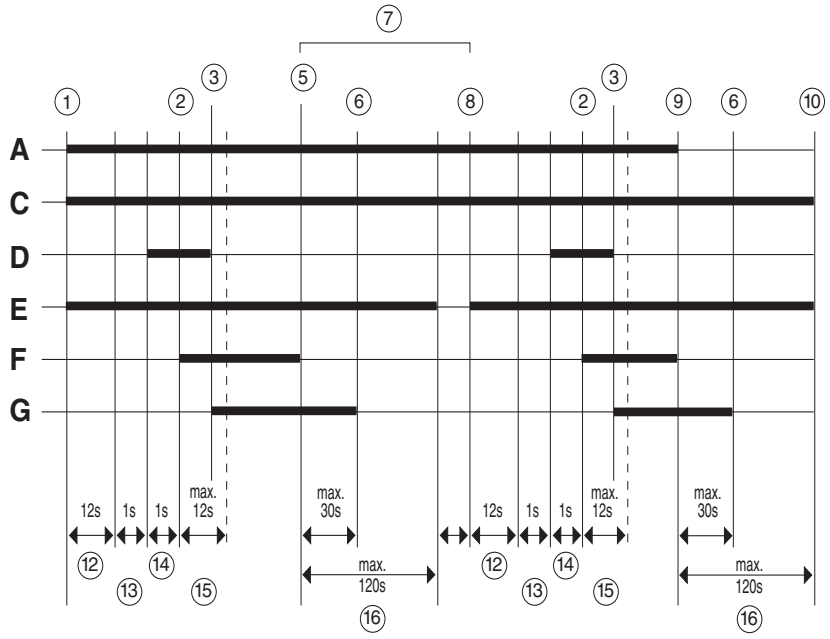
– no combustion for more than 10 seconds.

– temperature sensor short circuit during control idle.
– temperature sensor open circuit during combustion.
– flame sensor short circuit during combustion.
– solenoid valve short circuit during combustion.

Malfunctions during run-down:
Detection of a flame after more than 30 seconds after start of run-down with the circulation pump and combustion air fan maintaining operation for the following 90 seconds.

Malfunctions by overheating:
Overheating results in deactivation of the heater by the temperature limiter. After cool down of the unit and correction of the fault the button of the temperature limiter must be reset.

An error reset for a new start standby is achieved by switching the heater off and on again.



A	H1	Operating indicator light
C	M2	Circulation pump
D	U1	Igniter box
E	M1	Combustion air fan
F	Y1	Solenoid valve
G	B1	Flame sensor

1	Switch on
2	Start
3	Flame-up, combustion operation
5	Temperature sensor – upper switching threshold
6	Flame sensor – dark
7	Control idle
8	Temperature sensor – lower switching threshold
9	Switch off
10	Heater – off
12	Start-up
13	Foreign light check
14	Pre-ignition
15	Safety period
16	Run-down

Fig. 302:Functional sequence (heaters with control unit 1572D)

3.8 Switch-off upon Failure (heaters with control unit 1572D)

The heater switches off automatically when detecting one of the following malfunctions.
Several subsequent switch-offs due to a malfunction will cause the heater to enter an error lockout condition.

Flash pulses are output via the operating indicator light.
The combustion air fan and the circulation pump are switched off after approx. 120 seconds.

Malfunctions during switch-on:
Short or open circuit of
– temperature sensor
– flame sensor
– burner motor
– solenoid valve
– igniter box

Malfunctions during start-up:
– short circuit of igniter box
– open circuit of igniter box
– flame detected by photo control circuit prior to high voltage igniter spark.
– no flame detected after approximately 25 seconds after heater start.
– short/open circuit or dry run (if programmed) of circulation pump.
When using the circulation pump U 4851 approximately 15 seconds after switch-on the circulation pump is automatically stopped and may only be reactivated after approximately 2 minutes should coolant be missing or the pump wheel be seized.

Malfunctions during heating operation:
– low voltage threshold of approximately 21V violated for a duration of 20 seconds.
– no combustion for more than 10 seconds.
– temperature sensor short or open circuit.
– flame sensor short or open circuit.
– solenoid valve short or open circuit.

Malfunctions during heating operation:
(valid for application Thermo 350.190)
– low voltage threshold of approximately 18.5V violated for a duration of 20 seconds.
– no combustion for more than 10 seconds.
– temperature sensor short or open circuit.
– flame sensor short or open circuit.
– solenoid valve short or open circuit.

Malfunctions during run-down:
Detection of a flame after more than 30 seconds after start of run-down with the circulation pump and combustion air fan only maintaining operation for the following 90 seconds.

Malfunctions by overheating:
Overheating results in deactivation of the heater by the temperature limiter/thermostat. Dependent on heater configuration:
– the reset button on the temperature limiter must be reset.
– the reset of the thermostat is performed automatically after cool down.

An error reset for a new start standby is achieved by switching the heater off and on again.

Malfunctions by overheating of the burner (Thermo 231 and 301):
Overheating of the burner causes the overheat thermostat to initiate an error lockout at 150°C.
The solenoid valve closes, the fuel supply is cut off and a run-down is launched. An auto-reset occurs after cool-down of the thermostat.

3.9 Error Code Output (heaters with control unit 1572D)

When equipped with a standard timer an error code readout appears on the display of the timer after a malfunction.

NOTE
When the heater is operated by means of a switch the type of error is output during heater run-down via a flash code of the operating indicator light. After five short signals the long flash pulses are counted. The flash pulses correspond to the error number in the following table:

F 01 no start

F 02 flame-out

F 03 low voltage or excess voltage

F 04 foreign light detected during run-up and run-down

F 05 flame sensor defective

F 06 temperature sensor defective

F 07 solenoid valve defective

F 08 fan motor defective

F 09 circulation pump defective *

F 10 temperature limiter defective / overheating

F 11 igniter box defective

F 12 error lockout due to repeated malfunction or repeated flame-out
(8x no start-up or 5x flame-out)

* The error 09 is indicated only if the heater is equipped with a circulation pump monitoring (see table below).

Table: Programmed SG1572D with integrated circulation pump monitoring

EOL-Data record for SG 1572D			
EOL-Data record	Circulation pump monitoring		Ctr. device programmed
	Yes	No	
63317_			
63860_			
67980_	X		67981_
96774_			
97805_			
97807_	X		97810_
97809_	X		97810_
97811_	X		97812_
97813_			
97815_			

4 Technical Data

Where no threshold values are specified technical data are understood to include standard tolerances for heater units of ± 10% at ambient temperature of + 20 °C and at nominal voltage.

4.1 Electrical components

Control unit, fan and circulation pump motors, solenoid valve, igniter box, heater cartridge, nozzle block preheater and timer are 24V components. Temperature limiter, flame sensor, temperature sensor and switches are voltage independent components.

NOTE:
The allocation of circulation pumps to heater units must be in accordance with coolant resistances.

4.2 Fuel

Suitable fuel is the diesel fuel specified by the vehicle manufacturer.

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

Fuel	Requirements acc.	Remarks
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 14214	max. 20% see TI Fuels
Paraffinic diesel fuel from synthesis or hydro-genation (HVO)*	DIN EN 15940	only selected fuels see TI Fuels

* Further information on approved fuels contains the TI (Technical Information) Fuels.
It can be found on www.spheros.com in the download area.

In case of air temperatures below 0 °C a commercially available winter Diesel fuel, at temperatures below -18 °C a Diesel for arctic climate conditions 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.

Heater		Thermo 230	Thermo 231	Thermo 300	Thermo 301	Thermo 350
Type		**Thermo 230**	**Thermo 231**	**Thermo 300**	**Thermo 301**	**Thermo 350**
Mark of conformity up to 4/03		~ S230	~ S327	~ S229	~ S328	~ S228
EC type approval number e1*2001/56*		0007*--	0010*--	0008*--	0011*--	0009*--
Heater principle		High pressure atomizer				
Heating flow	KW (kcal/h)	23 (20 000)		30 (26 000)		35 (30 000)
Fuel		Diesel / fuel oil				
Fuel consumption	kg/h	2.9		3.3		3.7
Nominal voltage	V-	24				
Operating voltage	V-	20 ... 28				
Operating voltage (valid for application Thermo 350.190)	V-	19 ... 28				
Nominal power consumption (without circulation pump)	W	65		110		140
Permissible operating ambient temperature range (heater, control unit, circulation pump)	°C	–40 ... +85				
Permissible storage temperature	°C	+110 max.				
Permissible operating overpressure	bar	0.4 ... 2.0				
Heat exchanger capacity	l	1.8				
Minimum capacity of circuit	l	25				
CO_2 in exhaust at nominal voltage	Vol.-%	10 ±0.5 related to 500 m above S.L.				
CO_2 in exhaust at nominal voltage (valid for application Thermo 350.190)	Vol.-%	9.2 ... 10.1				
Dimensions heater (tolerance ± 3 mm)	mm mm mm	length 610 width 246 heigh 220				
Weight	kg	19				

Circulation pump		U 4814 Aquavent 5000	U 4854 Aquavent 5000S	U 4855 Aquavent 6000C	U4856 Aquavent 6000SC
Volume flow	l/h	5000 (against 0.2 bar)	5000 (against 0.2 bar)	6000 (against 0.4 bar)	6000 (against 0.4 bar)
Nominal voltage	V =	12 or 24	24	24	24
Operating voltage range	V =	10...14 / 20...28	20...28	20...28	20...28
Nominal power consumption	W	104	104	210	210
Dimensions		Lenght 230 Width 100 Height 103	Lenght 249 Width 100 Height 105	Lenght 226 Width 115 Height 118	Lenght 231 Width 115 Height 118
Weight	kg	2.1	2.2	2.4	2.5

Optional Fuel Filter Heater

Filter Heater		
Nominal power consumption	W	240
Nominal voltage	V -	24
Switch-on point	C°	0.5 ± 2.5
Switch-off point	C°	5.5 ± 2.5

5 Troubleshooting

5.1 General

This section describes troubleshooting procedures for the heaters *Thermo 230, 231, 300, 301* and *350*.

ATTENTION:

Troubleshooting requires profound knowledge about components of the heater and their theory of operation and may only be performed by trained personnel.

In case of doubt functional interrelations may be derived from Sections 2 and 3.

ATTENTION:

Troubleshooting is normally limited to the isolation of defective components.

The following possible causes for trouble have not been taken into consideration and must always be excluded as a possible cause for malfunction:

corrosion on connector
loose contact on connector
wrong crimping on connector
corrosion on wiring and fuses
corrosion on battery terminals

After any fault correction a functional checkout in the vehicle has to be performed.

5.2 General Fault Symptoms

The following table (Fig. 501) lists possible fault symptoms of general nature.

Error symptom	Possible cause
Error in the electrics	
Operation indicator does not light 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 operation indicator does not light.	Operation indicator defective or cables to the operation indicator interrupted or shorted.
Error in the water system	
Circulating pump not operating (only U 4851 and Aquavent 6000SC only).	• Failure mode activated The failure mode switches the motor off in case of malfunctions. After approx. 5 sec the failure mode switches the motor to the power saving sleep mode. In the sleep mode the internal consumers of the motor electronics are switched off. The power consumption in this mode then amounts to < 2 mA. The motor can be reactivated out of the sleep mode by disconnection of the power supply for approx. 2 minutes. After power reconnection the motor will again run up with a soft start.

Fig. 501 General Fault Symptoms (Sheet 1 of 3)

Error symptom	Possible cause
Heater stops as the connected heat exchangers provides insufficient heat.	<u>Flow rate too small, because</u> • Air in the heater, heat exchangers 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), wrong sense of rotation – check wiring colors (black + / brown –). • 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. • Heat exchanger of too low capacity.
Approximate flow rate determination: Flow rate in [l/h] = $\frac{\text{Heat flow [kW] according to type plate}}{\text{Temperature difference } \Delta t \text{ in [K] or [°C] measured on the heater between water inlet and water outlet (e.g. using contact thermometer)}} \times 860$	
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 filters or lines. • Venting opening in tank closed. • Fuel lines mixed up. • Fuel filter contaminated. • Fuel screen (filter) in pump contaminated.

Fig. 501 General Fault Symptoms (Sheet 2 of 3)

Error symptom	Possible cause
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 instructions. • Fuel pump defective (pump pressure). • Return line throttled • Screen (filter) in fuel pump contaminated. • O-ring seal on the fuel pump ineffective (aging prozess). • Atomizer nozzle defective. • Combustion air and exhaust lines throttled or closed. • Burner motor speed too low.

Fig. 501 General Fault Symptoms (Sheet 3 of 3)

5.3 Fault Symptoms during Functional Checkouts and Error Code Output or Tests with Diagnostic Computer, Components Tester or PC Heater Diagnosis

5.3.1 General

Error Code Output

NOTE:
Only heaters with a control unit 1572D provide an error code output.
When equipped with a standard timer an error code readout is available after a malfunction on the display of the timer.
When the heater is operated by means of a switch a coded flashing of the operating indicator light during run-down of the heater or until switch-off indicates the type of error (see 3.9).

Diagnostic Computer

NOTE:
Checks with the diagnostic computer may only be performed on heaters equipped with control unit 1572.

By use of the diagnostic computer heaters may be checked in the vehicle. The following tests are available:

- indication of measured values: water temperature, control unit supply voltage, flame sensor bright/dark.
- indication and erasure of faults stored in the control unit.

Operation of the diagnostic computer is menu controlled by means of four push button switches.

For details refer to operating instructions for "Diagnostic Computer".

Components Tester

NOTE:
Checks with the components tester may only be performed on heaters equipped with control unit 1572.

Using the components tester several types of faults and component malfunctions may be analyzed in the vehicle. The test of the individual components with the components tester is not intended. Faults like short or open circuits may be detected with the components tester but cannot be localized.

For details refer to operating instructions for "Components Tester".

PC Heater Diagnosis

By use of the PC heater diagnosis heaters (with control unit 1572 or 1572D) may be tested in the vehicle.

For details refer to operating instructions for "PC Heater Diagnosis".

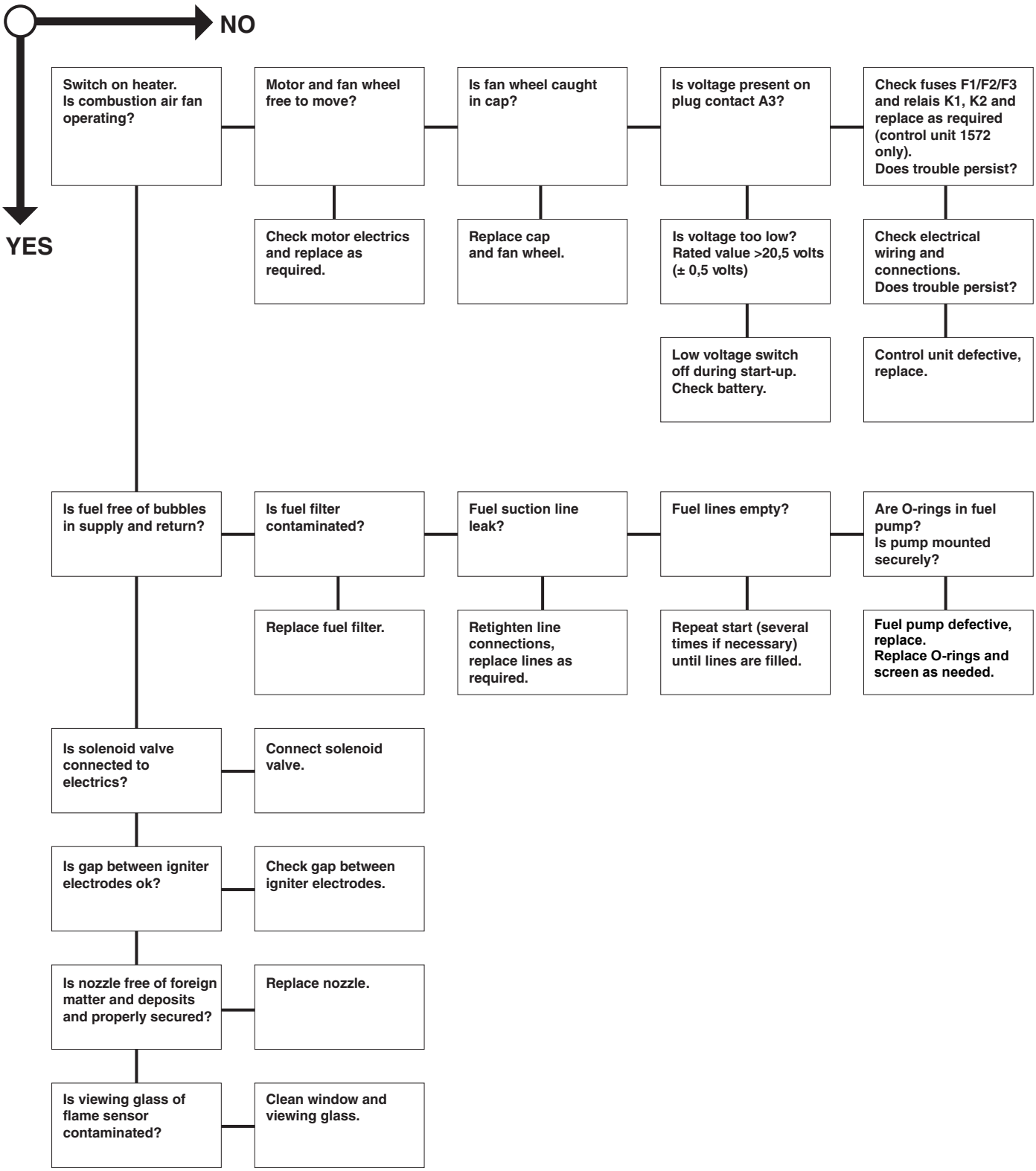
The up to date software is in the internet available.

5.3.2 Fault Symptoms

5.3.2.1 Fault Symptom "No Start"

NOTE

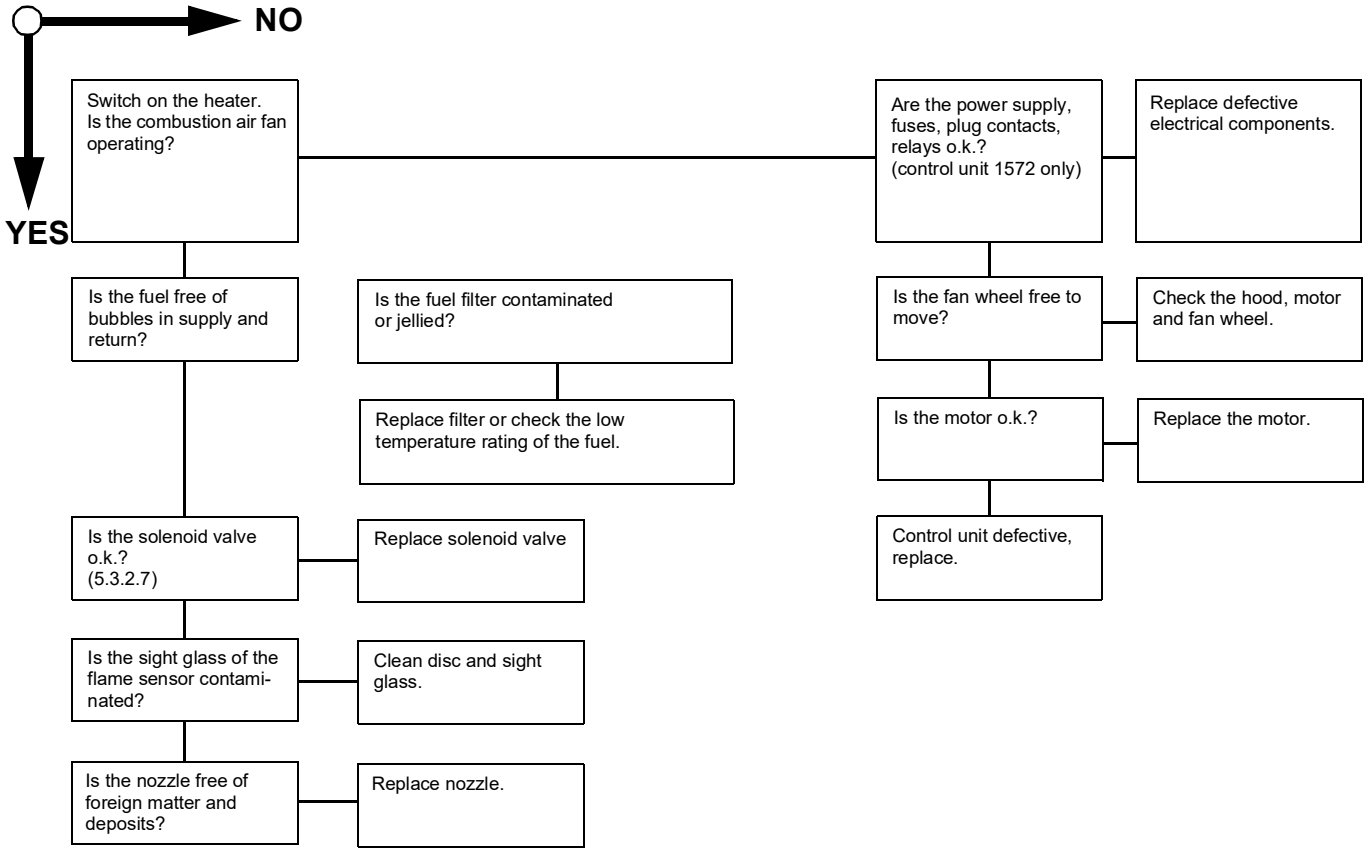
Heaters with control unit 1572D:
If the heater performs 8 subsequent attempts to start due to a malfunction, the heater enters an error lockout and stops any further attempts to start. This error lockout is superior to the normal error lockout condition.
The error lockout reset is achieved by switching the heater on and disconnection of the heater power supply during run-down.



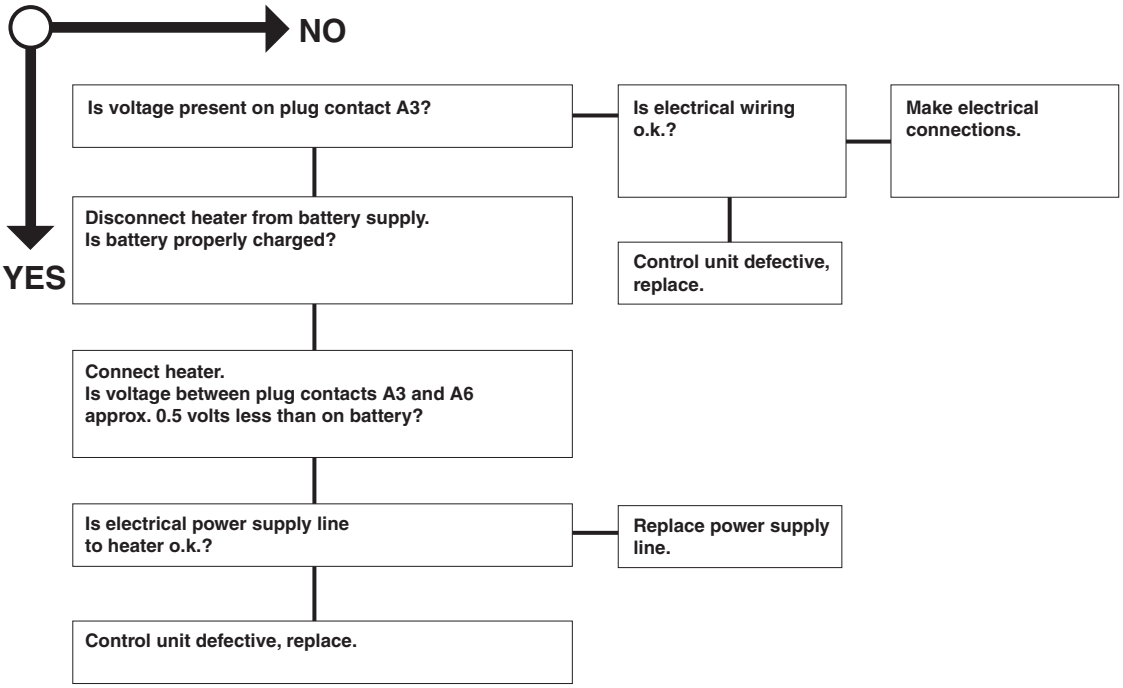
5.3.2.2 Fault Symptom "Flame-out"

NOTE:

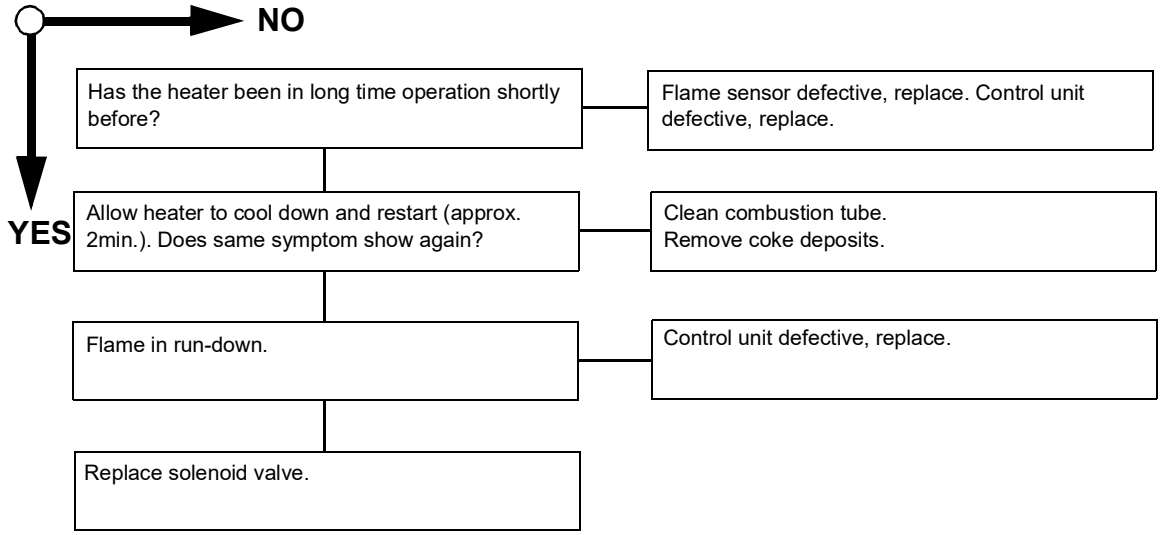
Heaters with control unit 1572D:
If the heater performs 5 subsequent attempts to start due to a malfunction, the heater enters an error lockout and stops any further attempts to start. This error lockout is superior to the normal error lockout condition.
The error lockout reset is achieved by switching the heater on and disconnection of the heater power supply during run-down.



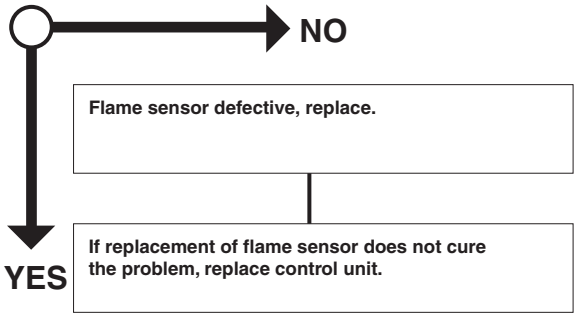
5.3.2.3 Fault Symptom "Low Voltage"



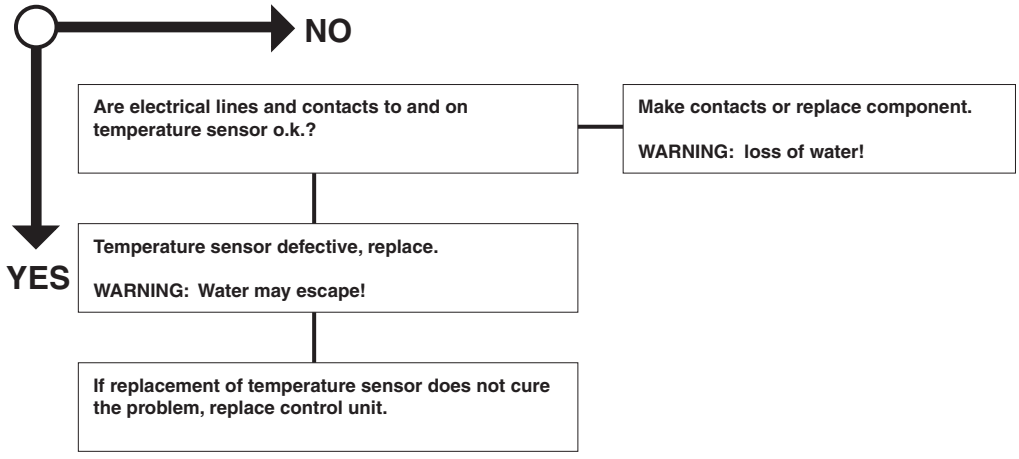
5.3.2.4 Fault Symptom "Foreign Light Detection during Run-up or Run-down"



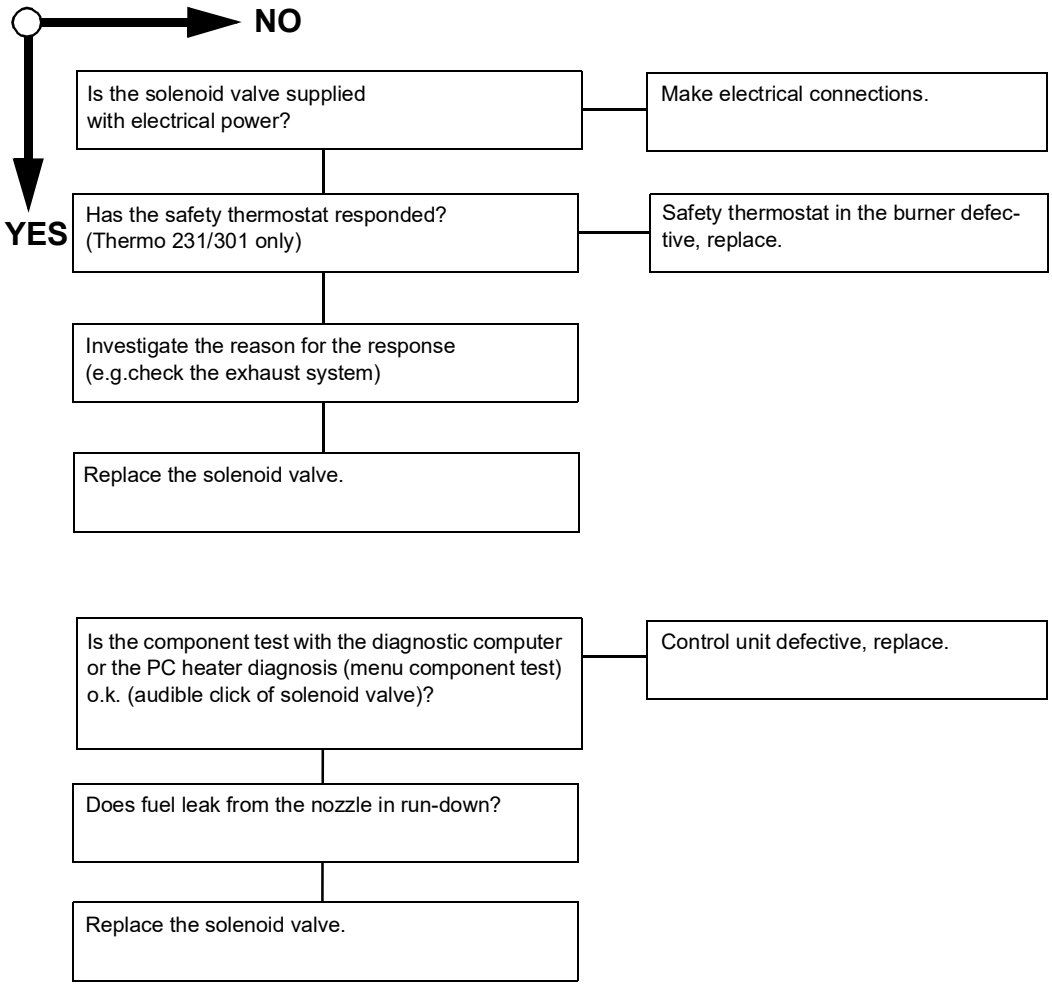
5.3.2.5 Fault Symptom "Flame Sensor Defective"



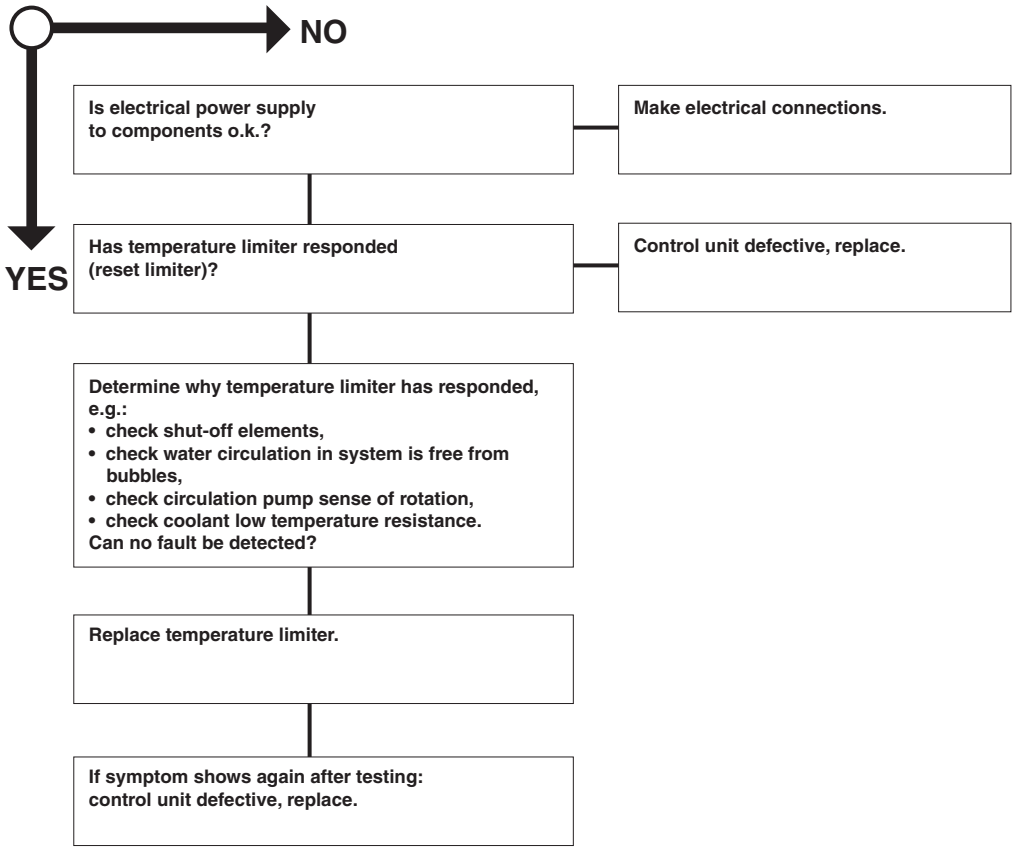
5.3.2.6 Fault Symptom "Temperature Sensor Defective"



5.3.2.7 Fault Symptom "Solenoid Valve Defective"



5.3.2.8 Fault Symptom "Temperature Limiter Defective"



6 Functional Checkouts

6.1 General

This section describes the tests and adjustments on the heater in installed and removed condition to prove its serviceability.

Warning!	**Danger of suffocation!**

The heater must not be operated in closed areas like garages or workshops with no exhaust ventilation facilities.

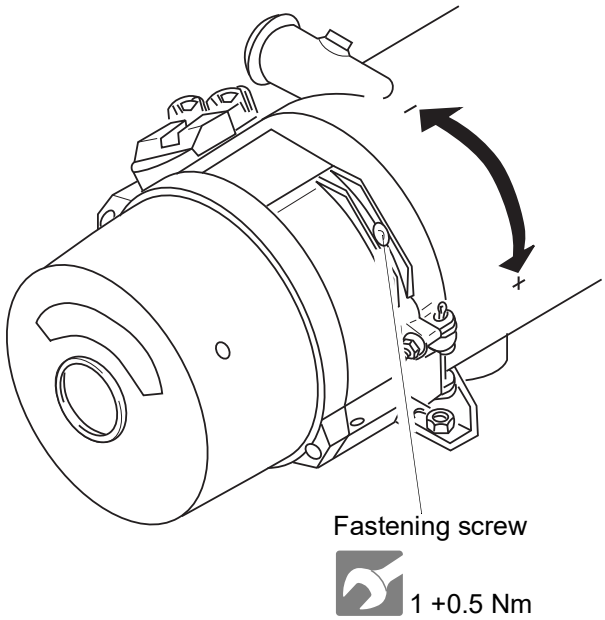
ATTENTION:

To prevent fires do not switch heater on with burner swung open.

6.2 Adjustments

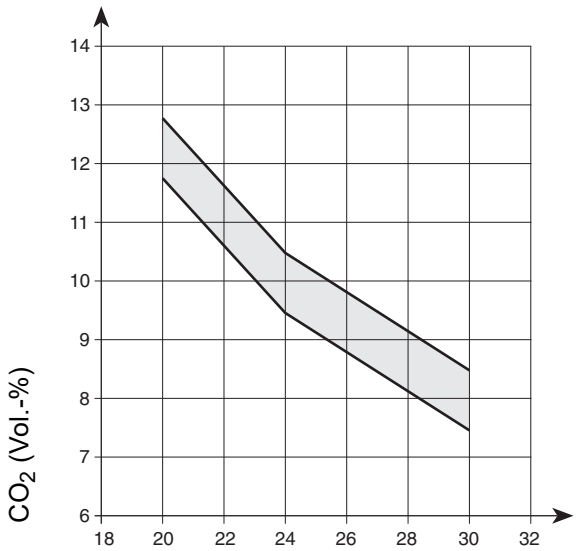
6.2.1 Adjustment of CO_2 Contents

It is allowed to change the manufacturer's setting for combustion air quantity by rotation of the setting ring.



Measurement of the CO_2 value of the exhaust gas must be performed followed by an adjustment of the combustion air quantity as required in case of:
- repairs on the burner
- irregularities in combustion
- functional checkouts
- nozzle replacement

Setting procedure
- measure control unit power supply voltage
- operate heater for approximately 5 min.
- measure CO_2 contents and soot level and compare with relevant diagram
- soot level target value acc. Bacharach ≤ 4
- loosen fastening screw (refer to Fig.) and reposition setting ring with fastening screw until rated value is obtained.
- tighten fastening screw and apply screw seal varnish.



CO_2 - setting at 500 m NN

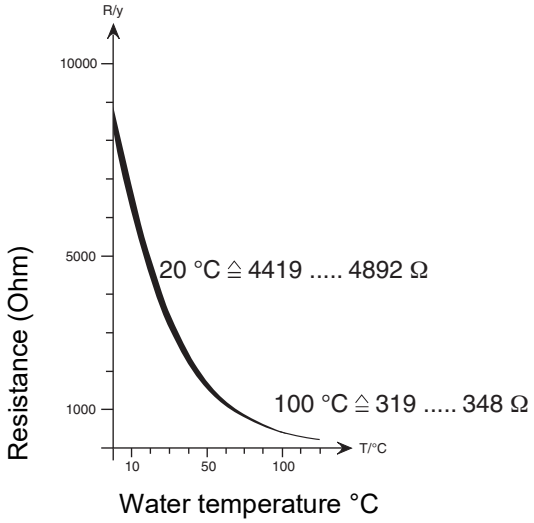
NOTE

CO_2 setting depends on fuel (viscosity) and on geodetic altitude (0.1 % per 100 m).
If proper setting cannot be obtained, proceed as follows:
- check burner head air side for damage and replace if required
- Check the fuel pump pressure acc. to para. 6.3.5 and readjust as necessary or replace the fuel pump.
- Inspect fuel filter and fuel pump filter (screen) for contamination and replace as needed.
- replace fuel nozzle
- measure burner motor speed

6.3 Components Testing

6.3.1 Temperature Sensor Resistance Check

When checking the temperature sensor with a digital multimeter the values of the following diagram must be obtained. Resistance checking is preferably performed at ambient temperatures between 20 °C and approximately 100 °C (immerse sensor in water).

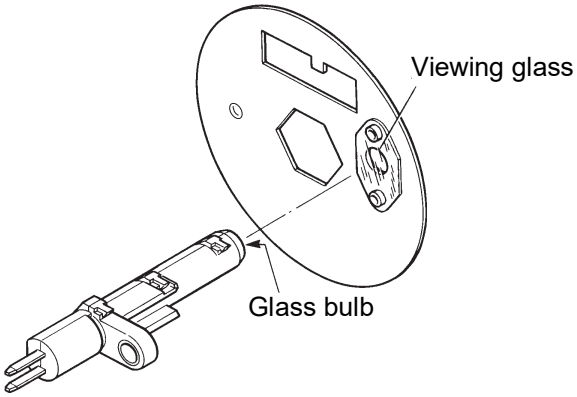


6.3.2 Flame Sensor Resistance Check

NOTE:
Testing is not carried out when a control unit with an integrated flame sensor is installed.

NOTE:
The glass bulb of the flame sensor and the viewing glass of the window (refer to Fig.) are to be cleaned if contaminated. In case of damage or not obtaining the rated values replace flame sensor.

Check
– cover flame sensor glass bulb
– check resistance (rated value: < 20 kOhm)
– uncover flame sensor glass bulb and expose to light of strong lamp.
– check resistance (rated value: < 400 Ohm)



6.3.3 Igniter Electrodes Check

NOTE:
The insulator of the igniter electrodes must show no damage. Igniter electrodes with a gap out of tolerance or not working properly must be replaced.

Check
– inspect insulators of igniter electrodes for damage

6.3.4 Igniter Box Check

NOTE:
The igniter box may also be tested using the PC heater diagnosis (component test).

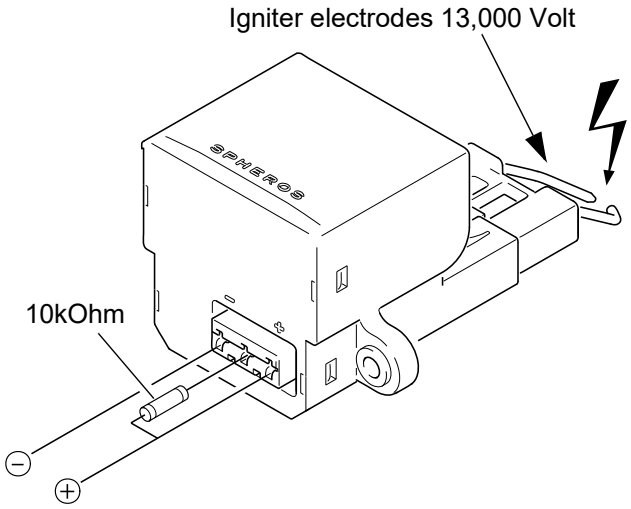
Warning!	**High voltage! Danger to life!**

High voltage; 13,000 volts arcing across the igniter electrodes.

ATTENTION:

Do not apply voltage to igniter box without electrodes.

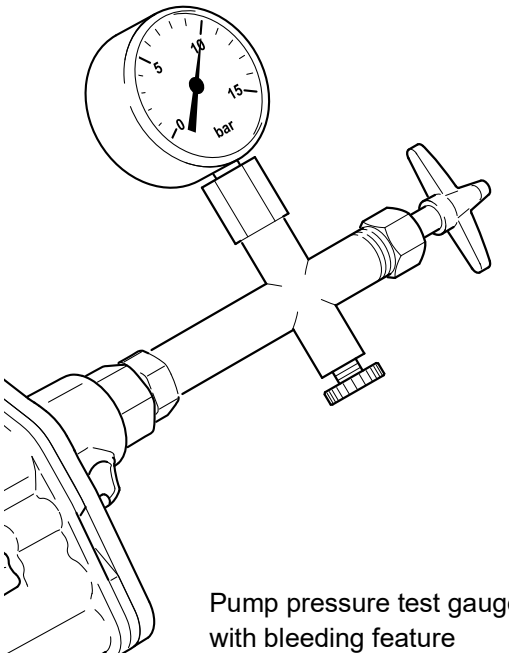
Check
– apply 24V as shown on figure
– normal condition: spark between electrodes.



6.3.5 Fuel Pump Check

6.3.5.1 Fuel Pump Check on Heaters with Control Unit 1572

A pressure test gauge with a display range from 0 to 15 bar as well as a bleeding feature is required (see Fig. below).



Pump pressure test gauge with bleeding feature

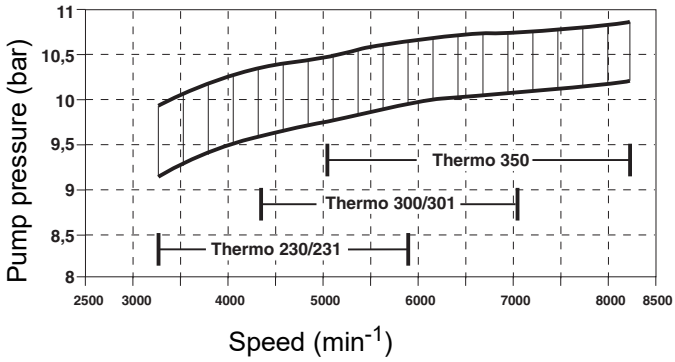
As prescribed, the fuel pump and the fuel hoses must be replaced every 5 years.

ATTENTION:

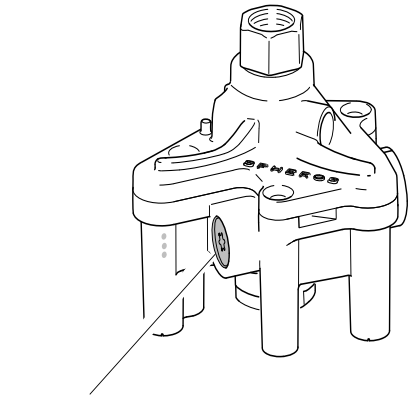
The igniter box must be removed for safety reasons.

Check

– remove igniter box (refer to 9.2.8.1).
– remove nozzle.
– screw on test gauge.
– cover flame sensor.
– switch on heater.
– 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.
– after approximately 13 sec. pump pressure is indicated (refer to diagram).
– If the specified pressure cannot be reached, it can be readjusted. For that rotate the adjusting screw (see Fig. below) max. one revolution. If the prescribed pressure despite readjustment not be achieved or occur leaks, the fuel pump must be replaced.
– switch off heater.
– unscrew test gauge.



Pump pressure in relation to speed



Adjustment screw pump pressure

Note: Pump displayed when removed.

ATTENTION:

Do not tuch or damage nozzle bore.

– Screw in nozzle and tighten (see 9.2.7.2).
– Install igniter box (refer to 9.2.8.2).

6.3.5.2 Fuel Pump Check on Heaters with Control Unit 1572D

NOTE:

The fuel pump check of heaters with control unit 1572D can also be done using the PC heater diagnosis in the menu component test.

As prescribed, the fuel pump and the fuel hoses must be replaced every 5 years.

Check

– remove nozzle.
– screw on the test gauge with bleeding feature.

– Follow the instructions in the menu component test of the PC heater diagnosis.
– 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.
– after approximately 13 sec. pump pressure is indicated (refer to the diagram above).
– If the specified pressure cannot be reached, it can be readjusted. For that rotate the adjusting screw max. one revolution. If the prescribed pressure despite readjustment not be achieved or occur leaks, the fuel pump must be replaced.
– screw in nozzle and torque with 20 Nm.

ATTENTION:

Do not tuch or damage nozzle bore.

6.3.6 Fan Motor Check

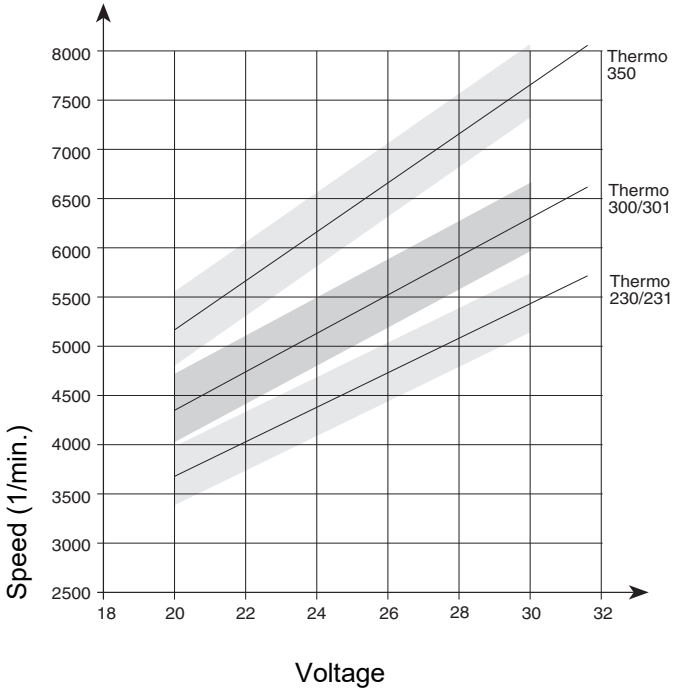
NOTE:

The fan motor check is performed with the burner installed. If normal conditions are not obtained the fan motor must be replaced.

Check

– check fan motor bearing condition(binding)
– measure heater power supply voltage
– switch on heater
– measure speed and compare with the diagram below

Thermo 230/231	4400 ±350	24 Volt
Thermo 300/301	5200 ±420	24 Volt
Thermo 230	6200 ±500	24 Volt



6.3.7 Solenoid Valve Check

NOTE:

A solenoid valve leaking valve seat shows by rather long smoke emissions during run-down. In this case fuel keeps dripping through the fuel nozzle.
Short smoke emissions are normal caused by clearing the area between solenoid valve and nozzle bore.

Check

ATTENTION:

Disconnect solenoid valve connector from control unit to avoid damage to the control unit.

– Check electrics for the following values:

• break voltage	17.0 Volts
• operating voltage	19.2 ... 28.8 Volts
• power consumption at nominal voltage and 20 °C	10 Watts
• nominal current	0.42 Amps

NOTE:

On heaters with control unit 1572 the solenoid valve may also be checked by means of the PC heater diagnosis (component test).

6.3.8 Nozzle Block Preheater Check

NOTE:

At a temperature of < 0 °C the heater cartridge in the nozzle block is activated. The heating period depends on the heat reflected within the combustion chamber.
Preheating is deactivated when the thermostat ambient temperature is +8 °C.
Power consumption is 130 ±13 Watts at 24 Volt.

Check

– swing burner head open or remove
– disconnect electrical connector from nozzle
– connect ohmmeter to connector
– using cooling spray cool down thermostat or bridge
– resistance (max. 4.5 Ω).

7 Circuit Diagrams

7.1 General

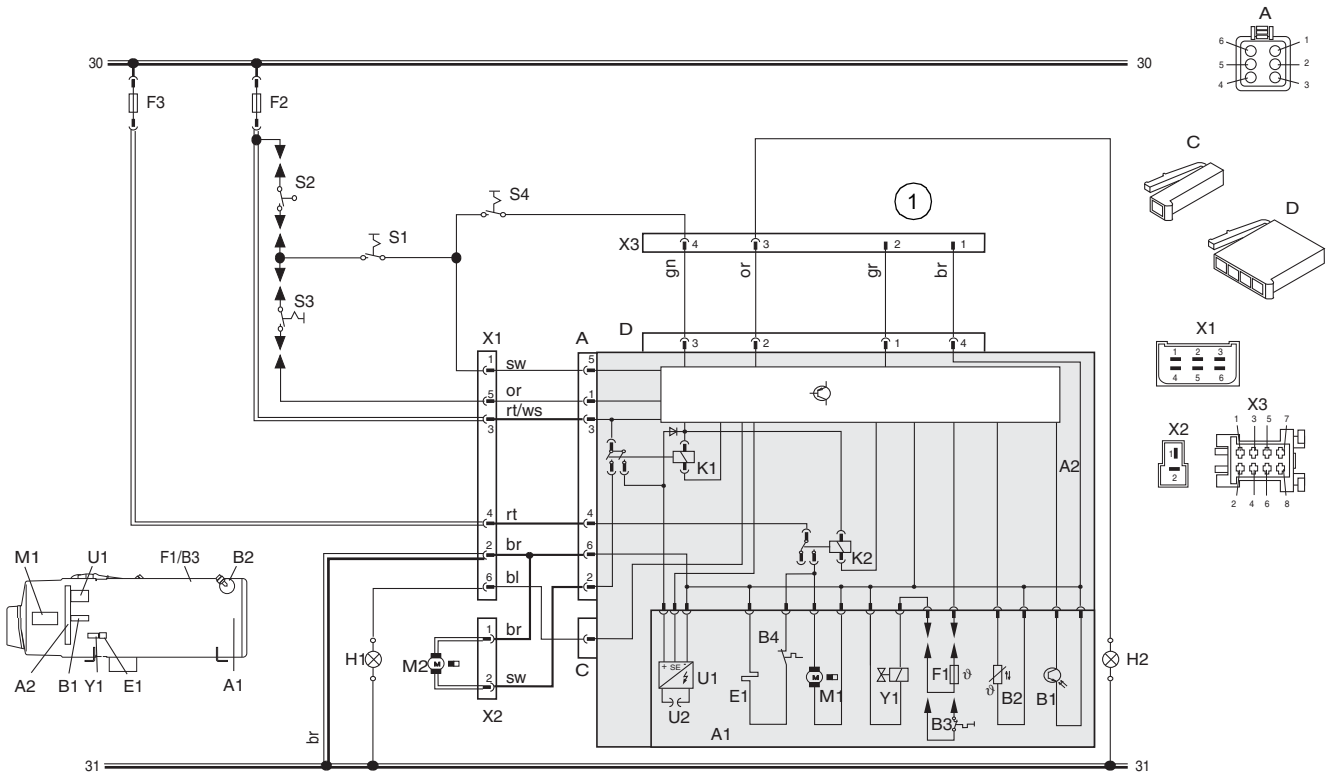
The circuit diagrams (Fig. 701 and 702) show possible heater circuits for *Thermo 230, 300* and *350* with control unit 1572 and with

– switch
– timer 1529 (triple timer)

The circuit diagrams (Fig. 703 and 704) show possible heater circuits for *Thermo 230, 231, 300, 301* and *350* with control unit 1572D and with

– switch
– standard timer 1531

The circuit diagrams (Fig. 705 thru 710) show possible heater circuits for *Thermo 230, 231, 300, 301* and *350* with control unit 1572D



1 Diagnostic connector

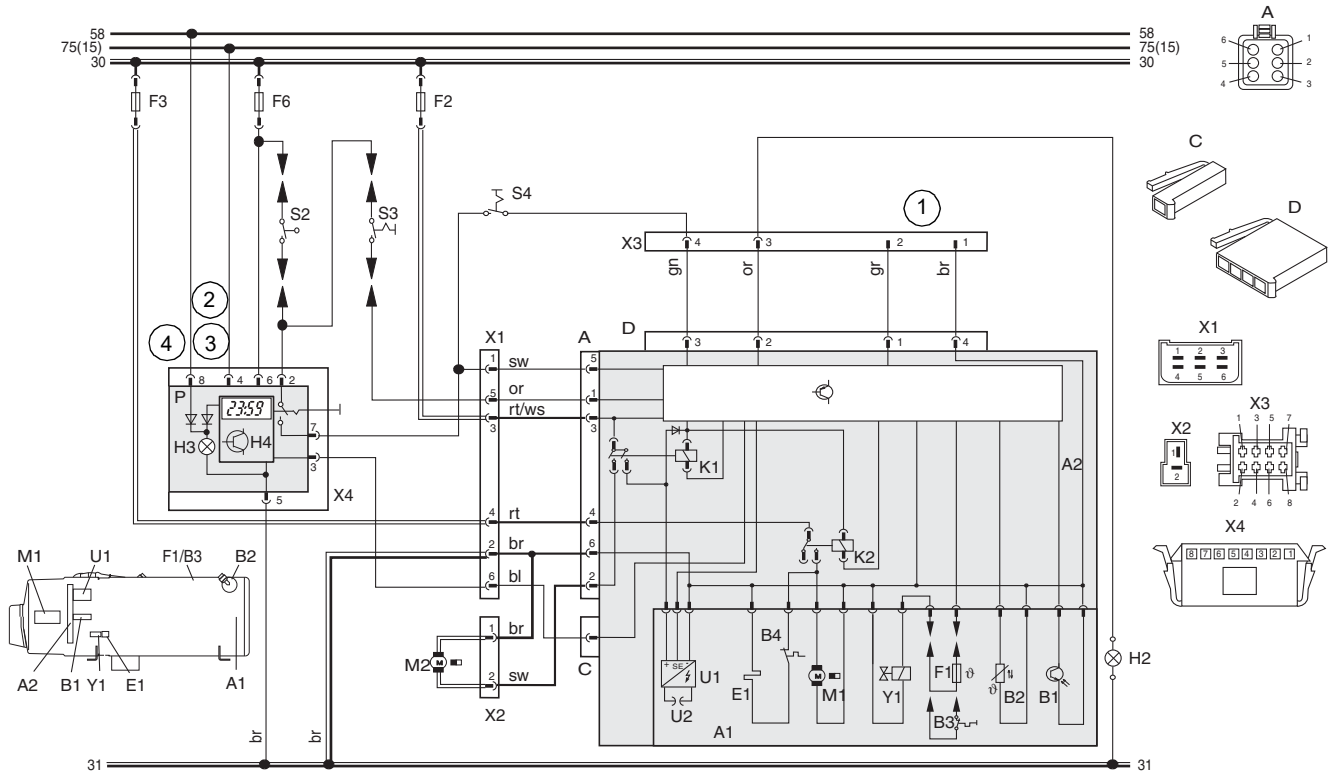
Leitungsquerschnitte		
	< 7,5 m	7,5 - 15 m
	0,75 mm²	1,5 mm²
	1,0 mm²	1,5 mm²
	1,5 mm²	2,5 mm²
	2,5 mm²	4,0 mm²
	4,0 mm²	6,0 mm²

Leitungsfarben	
bl	blau
br	braun
ge	gelb
gn	grün
gr	grau
or	orange
rt	rot
sw	schwarz
vi	violett
ws	weiß

Item	Nomenclature	Remark
A1	Heater	not grounded
A2	Control unit	SG 1572
B1	Flame sensor	
B2	Temperature sensor	
B3	Temperature limiter	
B4	Thermostat	open at T > 8 °C
E1	Heating cartridge	for nozzle preheating
F2	Fuse 25A	flat fuse SAE J 1284
F3	Fuse 25A	flat fuse SAE J 1284
H1	Light	operation indicator light
K1	Relay (in item A2)	for circulation pump
K2	Relay (in item A2)	for combustion air fan / heating cartridge
M1	Motor	combustion air fan
M2	Motor	circulation pump
S1	Switch	on / off
S2	Continuity switch	on water cock

Item	Nomenclature	Remark
S3	Switch, Ext. pump trigger	
S4	Switch	power save operation
U1	Igniter box	
U2	Igniter electrodes	
A	Plug connections, 6-pole	
C	Plug connections, 1-pole	
D	Plug connections, 4-pole	
X1	Plug connections, 6-pole	
X2	Plug connections, 2-pole	
X3	Plug connections, 8-pole	
Y1	Solenoid valve	

Fig. 701: Automatic Control Circuit with Control Unit 1572 and Switch



Leitungsfarben	
bl	blau
br	braun
ge	gelb
gn	grün
gr	grau
or	orange
rt	rot
sw	schwarz
vi	violett
ws	weiß

(1) Diagnostic connector

(2) to vehicle terminal +75 if available, otherwise terminal 15

(3) Timer P:
with plus to connection 4 = continuous operation during immediate heating
without plus to connection 4 = heating period 1 hour

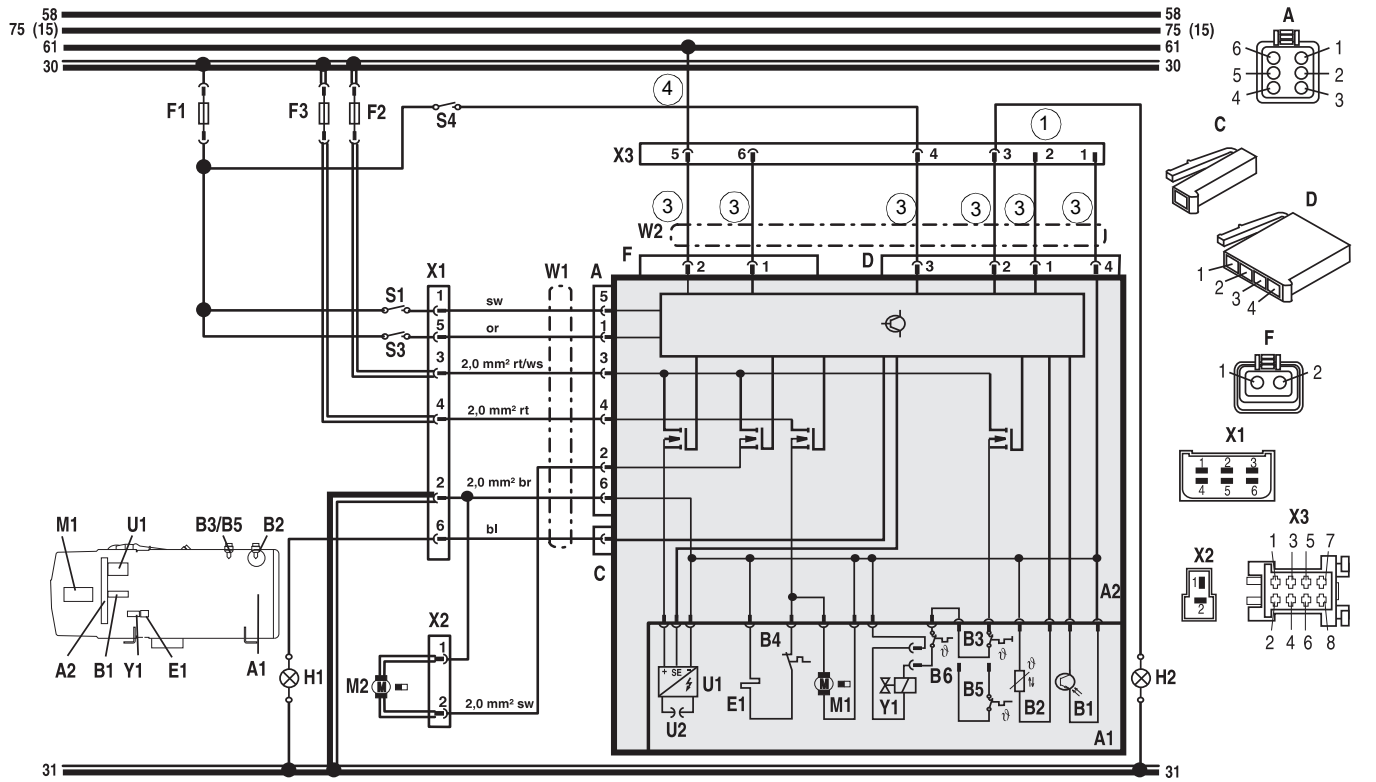
(4) vehicle lighting terminal 58

Leitungsquerschnitte		
	< 7,5 m	7,5 - 15 m
	0,75 mm²	1,5 mm²
	1,0 mm²	1,5 mm²
	1,5 mm²	2,5 mm²
	2,5 mm²	4,0 mm²
	4,0 mm²	6,0 mm²

Item	Nomenclature	Remark
A1	Heater	not grounded
A2	Control unit	SG 1572
B1	Flame sensor	
B2	Temperature sensor	
B3	Temperature limiter	
B4	Thermostat	open at T > 8 °C
E1	Heating cartridge	for nozzle preheating
F2	Fuse 25A	flat fuse SAE J 1284
F3	Fuse 25A	flat fuse SAE J 1284
F6	Fuse 5A	flat fuse SAE J 1284
H3	Light in pos. P	symbol lighting
H4	Symb. “Heating“ on display	operation indicator light
K1	Relay (in item A2)	for circulation pump
K2	Relay (in item A2)	for combustion air fan / heating cartridge
M1	Motor	combustion air fan
M2	Motor	circulation pump
P	Pre-selection timer (1529)	for pre-selection operation

Item	Nomenclature	Remark
S2	Continuity switch	on water cock
S3	Switch, Ext. pump trigger	
S4	Switch	power save operation
U1	Igniter box	
U2	Igniter electrodes	
A	Plug connections, 6-pole	
C	Plug connections, 1-pole	
D	Plug connections, 4-pole	
X1	Plug connections, 6-pole	
X2	Plug connections, 2-pole	
X3	Plug connections, 8-pole	
X4	Plug connections, 8-pole	
Y1	Solenoid valve	

Fig. 702: Automatic Control Circuit with Control Unit 1572 and Timer (Triple Timer)



(1) Diagnostic connector

(3) Pin assignment:

Pin assignment	4wire lead	7wire lead
D1	0,75 gr	0,75 rt
D2	0,75 or	0,75 or
D3	0,75 gn	0,75 bl
D4	0,75 br	2,0 br
F1	nicht belegt	2,0 sw
F2	nicht belegt	2,0 rt/ws

(4) with connection to terminal 61 auxiliary

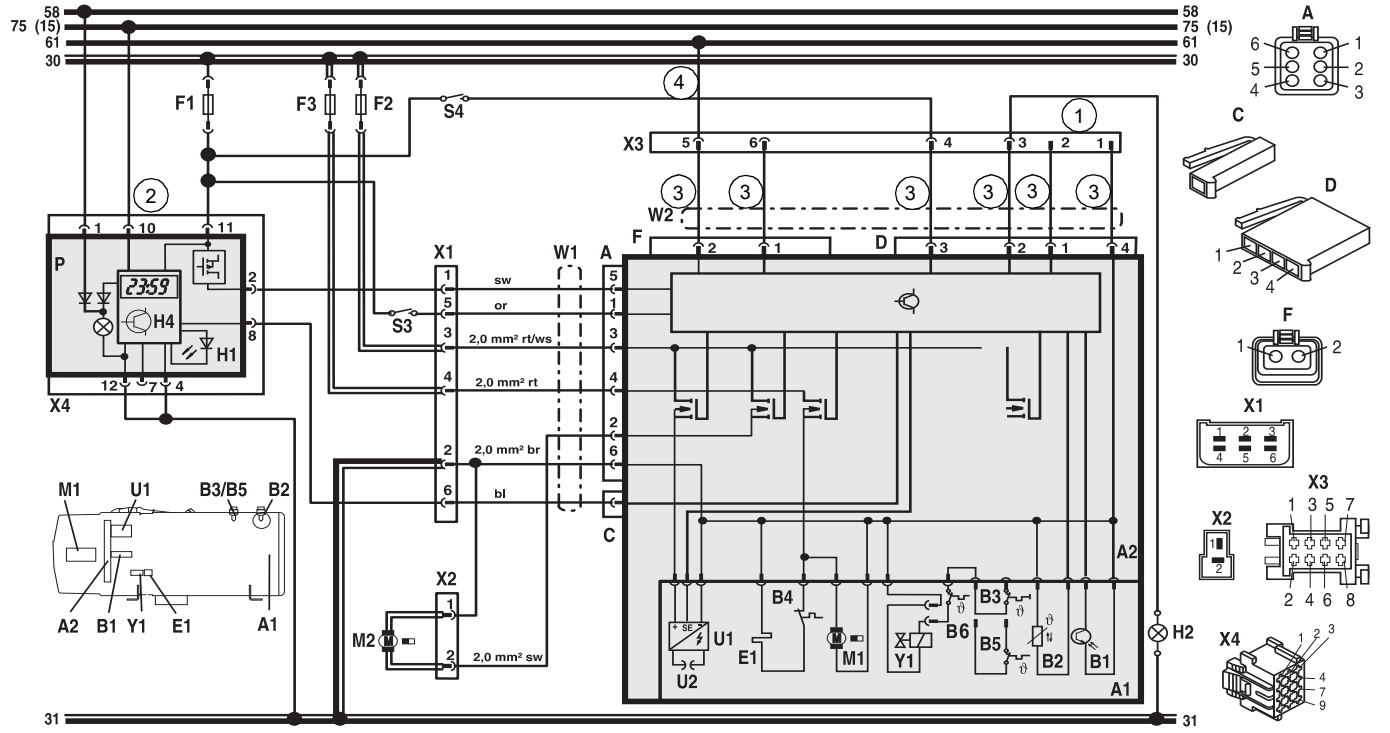
Leitungsquerschnitte	< 7,5 m	7,5 - 15 m
———	0,75 mm²	1,5 mm²
— — —	1,0 mm²	1,5 mm²
▬▬▬	1,5 mm²	2,5 mm²
═══	2,5 mm²	4,0 mm²
▬▬▬	4,0 mm²	6,0 mm²

Leitungsfarben	
bl	blau
br	braun
ge	gelb
gn	grün
gr	grau
or	orange
rt	rot
sw	schwarz
vi	violett
ws	weiß

Item	Nomenclature	Remark
A1	Heater	not grounded
A2	Control unit	SG 1572
B1	Flame sensor	observe polarity
B2	Temperature sensor	polarity optional
B3	Temperature limiter	
B4	Thermostat	for nozzle preheating
B5	Thermostat	alternative to B3
E1	Heating cartridge	for nozzle preheating
F1	Fuse 5A	flat fuse acc. DIN 72581 part 3
F2	Fuse 25A	flat fuse acc. DIN 72581 part 3
F3	Fuse 25A	flat fuse acc. DIN 72581 part 3
H1	Light	operation indicator light
H2	Light	flame indication light
M1	Motor	combustion air fan
M2	Motor	circulation pump
S1	Switch	on / off

Item	Nomenclature	Remark
S3	Switch	ext. pump trigger
S4	Switch	power save operation
U1	Igniter box	
U2	Igniter electrodes	
W1	wire harness (1)	
W2	wire harness (2)	
A	Plug connections, 6-pole	
C	Plug connections, 1-pole	
D	Plug connections, 4-pole	
F	Plug connections, 2-pole	
X1	Plug connections, 6-pole	
X2	Plug connections, 2-pole	
X3	Plug connections, 8-pole	
Y1	Solenoid valve	

Fig. 703: Automatic Control Circuit with Control Unit 1572D and Switch



(1) Diagnostic connector

(2) Timer P:
with plus to connection 10 = continuous operating during immediate heating
terminal 10 not connected = duration of heating programmable (10 min to 120 min);

(3) Pin assignment:

Pin assignment	4wire lead	7wire lead
D1	0,75 gr	0,75 rt
D2	0,75 or	0,75 or
D3	0,75 gn	0,75 bl
D4	0,75 br	2,0 br
F1	not used	2,0 sw
F2	not used	2,0 rt/ws

Leitungsquerschnitte

	< 7,5 m	7,5 - 15 m
	0,75 mm²	1,5 mm²
	1,0 mm²	1,5 mm²
	1,5 mm²	2,5 mm²
	2,5 mm²	4,0 mm²
	4,0 mm²	6,0 mm²

Leitungsfarben

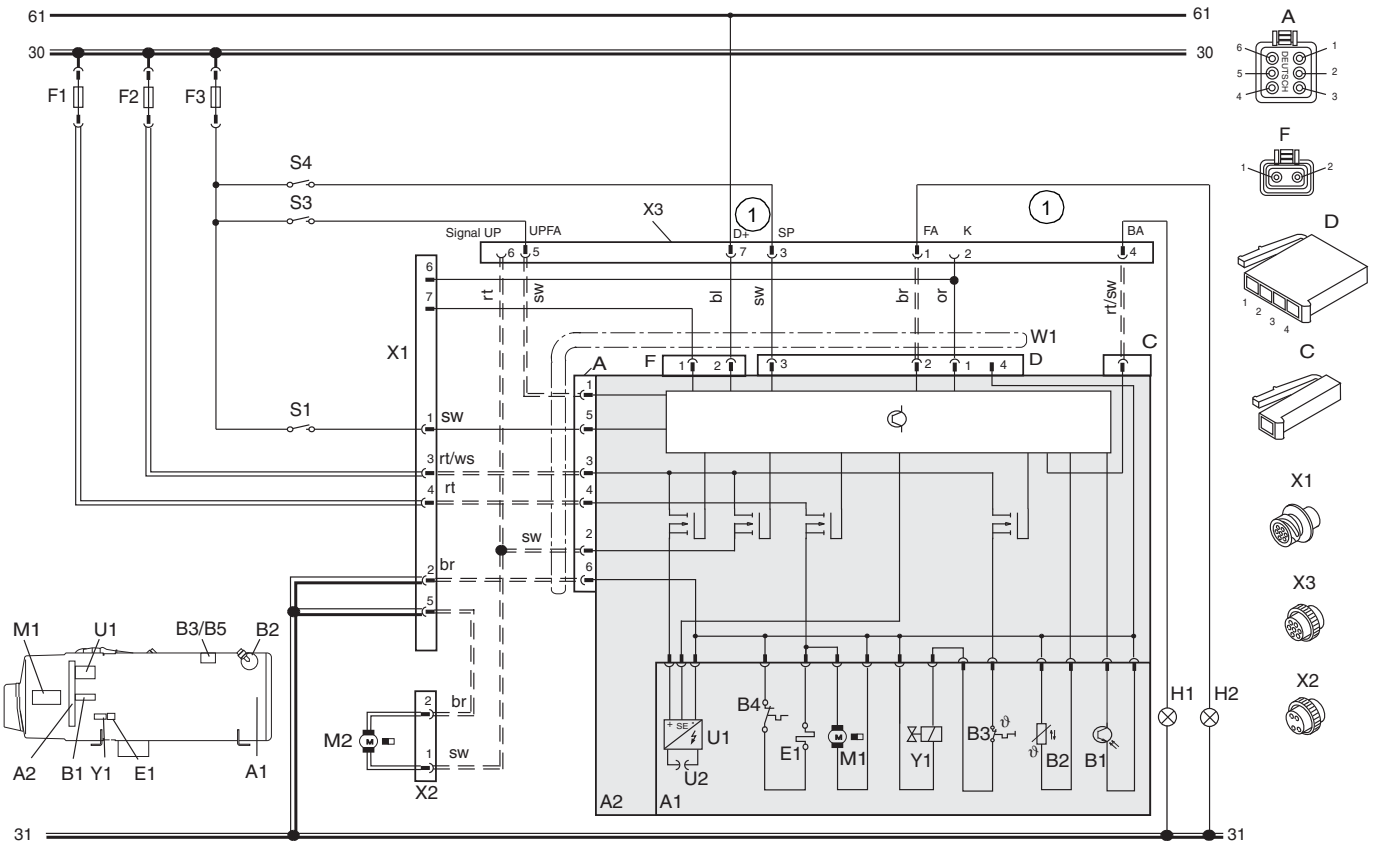
bl	blau
br	braun
ge	gelb
gn	grün
gr	grau
or	orange
rt	rot
sw	schwarz
vi	violett
ws	weiß

(4) with connection to terminal 61 auxiliary

Item	Nomenclature	Remark
A1	Heater	
A2	Control unit	SG 1572D
B1	Flame sensor	observe polarity
B2	Temperature sensor	polarity optional
B3	Temperature limiter	
B4	Thermostat	for nozzle preheating
B5	Thermostat	alternative to B3
E1	Heating cartridge	for nozzle preheating
F1	Fuse 5A	flat fuse acc. DIN 72581 part 3
F2	Fuse 25A	flat fuse acc. DIN 72581 part 3
F3	Fuse 25A	flat fuse acc. DIN 72581 part 3
H1	Light	operation indicator light
H2	Light	flame indication light
H4	Symb. “Heating“ on display	operation indicator light (in pos. P)
M1	Motor	combustion air fan
M2	Motor	circulation pump
P	Pre-selection timer	for pre-selection operation

Item	Nomenclature	Remark
S3	Switch	ext. pump trigger
S4	Switch	power save operation
U1	Igniter box	
U2	Igniter electrodes	
W1	wire harness (1)	
W2	wire harness (2)	
A	Plug connections, 6-pole	
C	Plug connections, 1-pole	
D	Plug connections, 4-pole	
F	Plug connections, 2-pole	
X1	Plug connections, 6-pole	
X2	Plug connections, 2-pole	
X3	Plug connections, 8-pole	
X4	Plug connections, 12-pole	
Y1	Solenoid valve	

Fig. 704: Automatic Control Circuit with Control Unit 1572D and Standard Timer



(1) Diagnostic connector

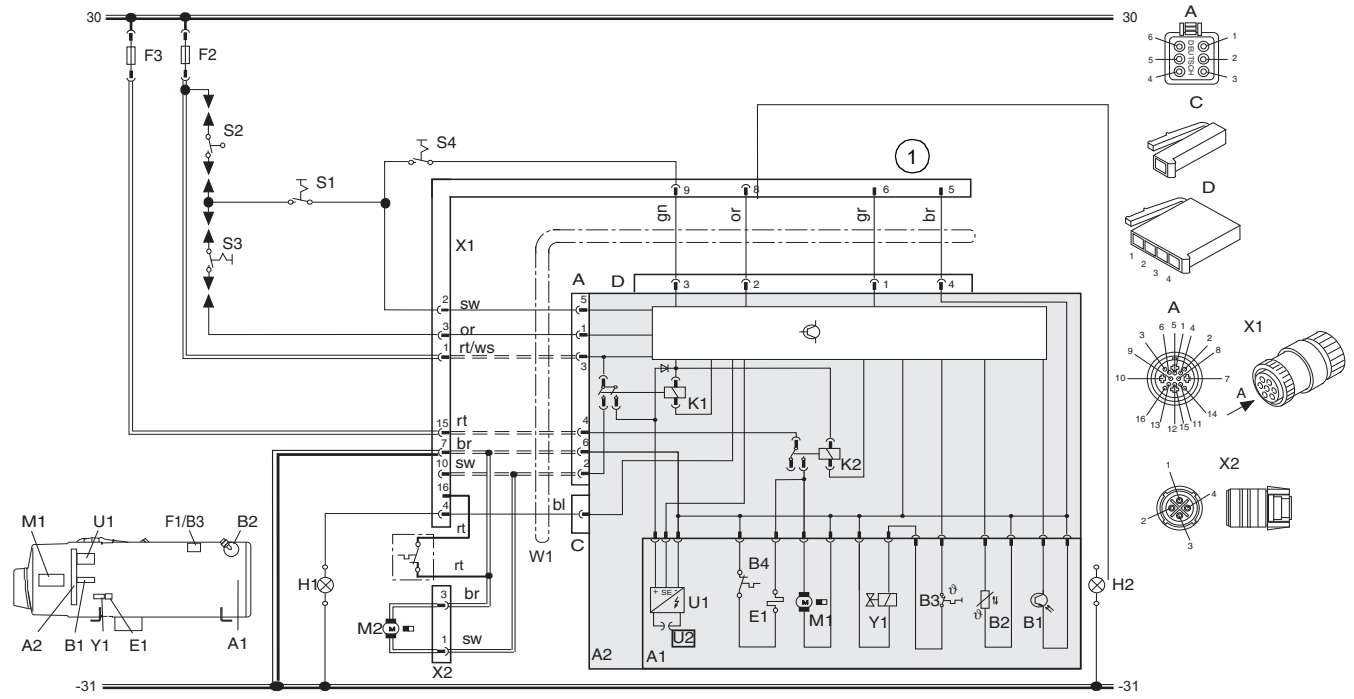
Leitungsfarben	
bl	blau
br	braun
ge	gelb
gn	grün
gr	grau
or	orange
rt	rot
sw	schwarz
vi	violett
ws	weiß

Leitungsquerschnitte		
	< 7,5 m	7,5 - 15 m
———	0,75 mm²	1,5 mm²
— —	1,0 mm²	1,5 mm²
———	1,5 mm²	2,5 mm²
———	2,5 mm²	4,0 mm²
———	4,0 mm²	6,0 mm²

Item	Nomenclature	Remark
A1	Heater	
A2	Control unit	SG 1572D
B1	Flame sensor	observe polarity
B2	Temperature sensor	polarity optional
B3	Temperature limiter	
B4	Thermostat	for nozzle preheating
E1	Heating cartridge	for nozzle preheating
F1	Fuse 25A	flat fuse acc. DIN 72581 part 3
F2	Fuse 25A	flat fuse acc. DIN 72581 part 3
F3	Fuse 5A	flat fuse acc. DIN 72581 part 3
H1	Light	operation indicator light
H2	Light	flame indication light
M1	Motor	combustion air fan
M2	Motor	circulation pump
S1	Switch	on / off

Item	Nomenclature	Remark
S3	Switch	ext. pump trigger
S4	Switch	power save operation
U1	Igniter box	
U2	Igniter electrodes	
W1	wire harness (1+2)	
A	Plug connections, 6-pole	
C	Plug connections, 1-pole	
D	Plug connections, 4-pole	
F	Plug connections, 2-pole	
X1	Plug connections, 7-pole	
X2	Plug connections, 2-pole	
X3	Plug connections, 7-pole	
Y1	Solenoid valve	

Fig. 705: System wiring diagram Daimler Chrysler Citaro, Ident no. 67131



Fuses acc. to SAE J 1284			
	DW230	DW300	DW350
F2	25A / 16A	25A / 16A	25A / 16A
F3	25A / 16A	25A / 16A	25A / 16A

Leitungsfarben	
bl	blau
br	braun
ge	gelb
gn	grün
gr	grau
or	orange
rt	rot
sw	schwarz
vi	violett
ws	weiß

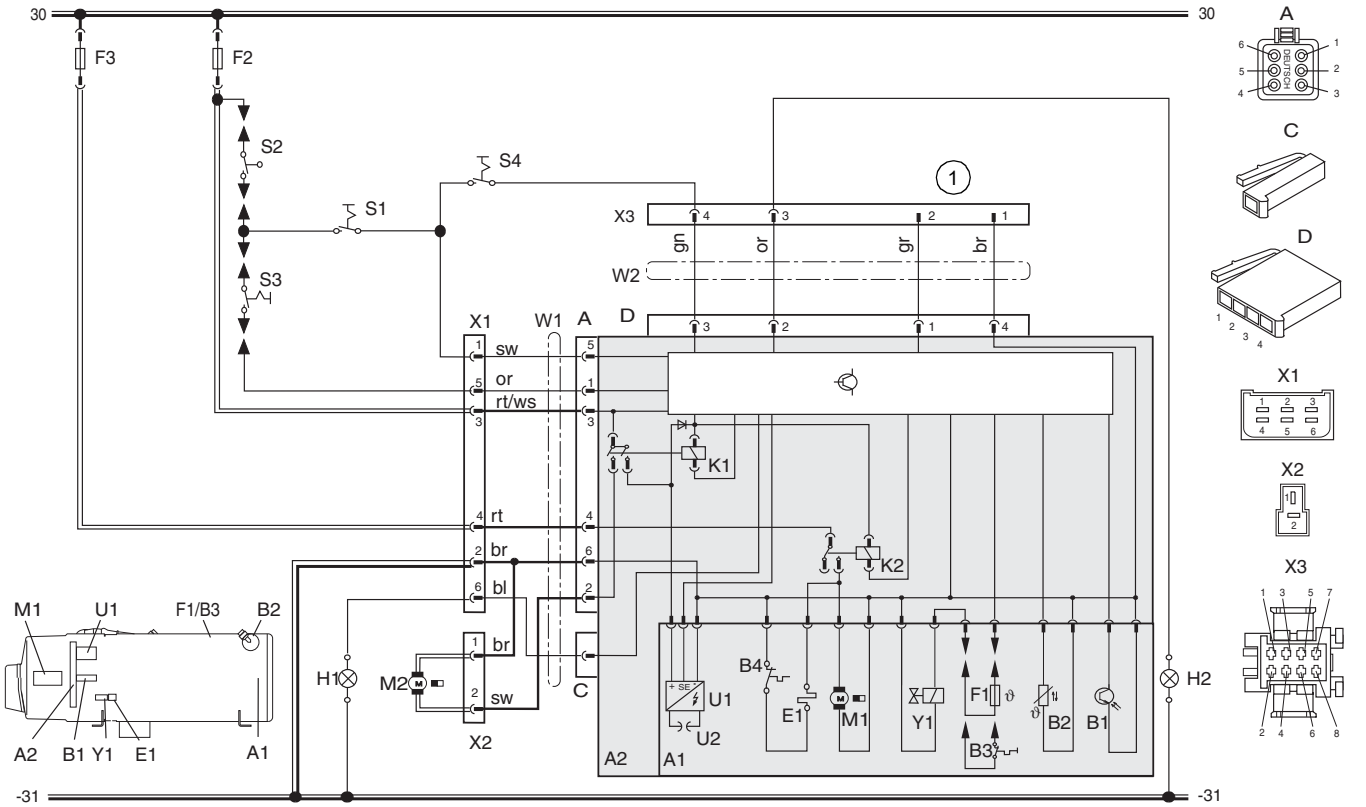
Leitungsquerschnitte		
	< 7,5 m	7,5 - 15 m
	0,75 mm²	1,5 mm²
	1,0 mm²	1,5 mm²
	1,5 mm²	2,5 mm²
	2,5 mm²	4,0 mm²
	4,0 mm²	6,0 mm²

(1) Diagnostic connector

Item	Nomenclature	Remark
A1	Heater	not grounded
A2	Control unit	SG 1572
B1	Flame sensor	observe polarity
B2	Temperature sensor	polarity optional
B3	Temperature limiter	alternative to F1
B4	Thermostat	for nozzle preheating
B5	Fire guard	Van Hool
E1	Heating cartridge	
F2	Fuse	see table
F3	Fuse	see table
H1	Light	operation indicator
H2	Light	flame indicator
K1	Relay	for circulation pump
K2	Relay	for combustion air fan
M1	Motor	combustion air fan
M2	Motor	circulation pump
S1	Switch	on / off

Item	Nomenclature	Remark
S2	Continuity switch	on water cock
S3	Switch, Ext. pump trigger	required, if S2 does not exist
S4	Switch	power save operation
U1	Igniter box	
U2	Igniter electrodes	
W1	Wiring harness	Van Hool
A	Plug connections, 6-pole	
C	Plug connections, 1-pole	
D	Plug connections, 4-pole	
X1	Plug connections, 16-pole	
X2	Plug connections, 4-pole	
Y1	Solenoid valve	

Fig. 706: System wiring diagram Van Hool, Ident no. 89401



Fuses acc. to SAE J 1284			
	DW230	DW300	DW350
F2	25A / 16A	25A / 16A	25A / 16A
F3	25A / 16A	25A / 16A	25A / 16A

Leitungsfarben	
bl	blau
br	braun
ge	gelb
gn	grün
gr	grau
or	orange
rt	rot
sw	schwarz
vi	violett
ws	weiß

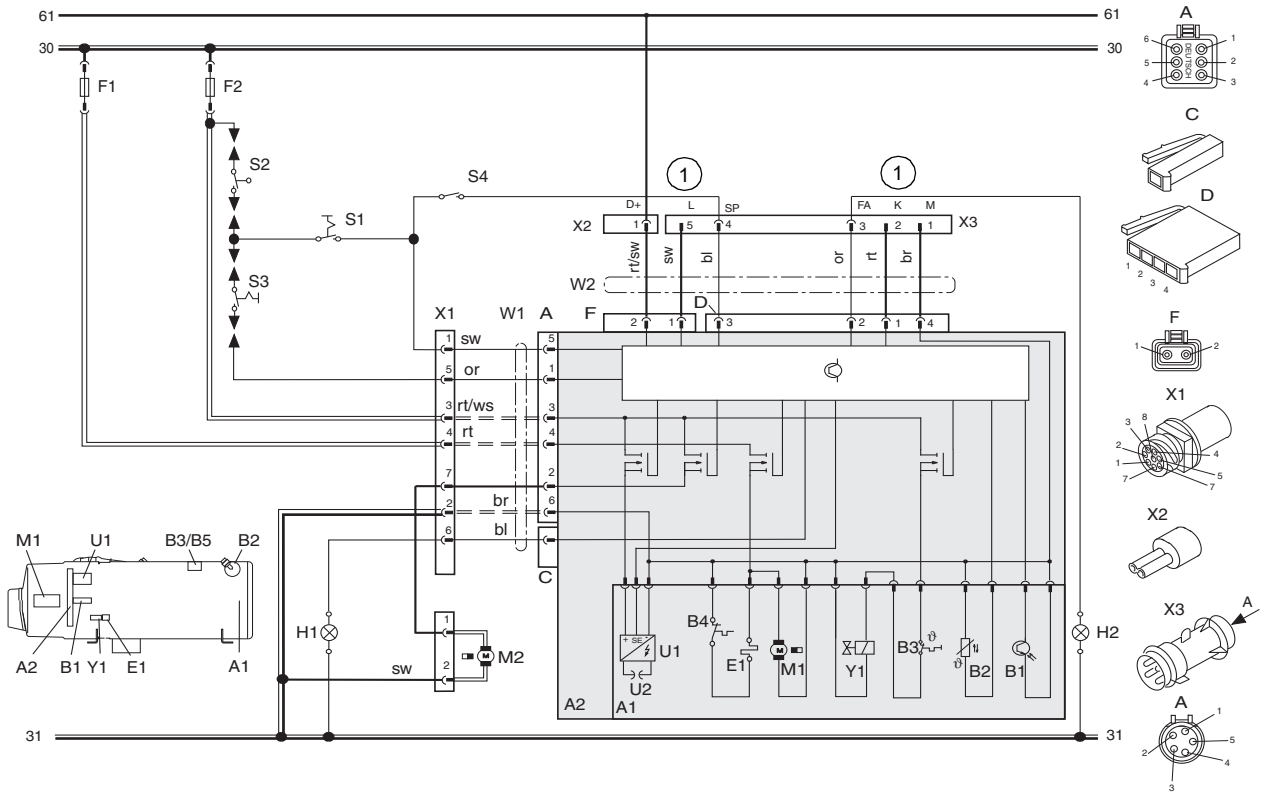
Leitungsquerschnitte		
	< 7,5 m	7,5 - 15 m
	0,75 mm²	1,5 mm²
	1,0 mm²	1,5 mm²
	1,5 mm²	2,5 mm²
	2,5 mm²	4,0 mm²
	4,0 mm²	6,0 mm²

(1) Diagnostic connector

Item	Nomenclature	Remark
A1	Heater	not grounded
A2	Control unit	SG 1572
B1	Flame sensor	observe polarity
B2	Temperature sensor	polarity optional
B3	Temperature limiter	alternative to F1
B4	Thermostat	for nozzle preheating
E1	Heating cartridge	
F2	Fuse	see table
F3	Fuse	see table
H1	Light	operation indicator
H2	Light	flame indicator
K1	Relay	for circulation pump
K2	Relay	for combustion air fan
M1	Motor	combustion air fan
M2	Motor	circulation pump
S1	Switch	on / off

Item	Nomenclature	Remark
S2	Continuity switch	on water cock
S3	Switch, Ext. pump trigger	required, if S2 does not exist
S4	Switch	power save operation
U1	Igniter box	
U2	Igniter electrodes	
W1	Wiring harness (1)	
W2	Wiring harness (2)	
A	Plug connections, 6-pole	
C	Plug connections, 1-pole	
D	Plug connections, 4-pole	
X1	Plug connections, 6-pole	
X2	Plug connections, 2-pole	
X3	Plug connections, 8-pole	
Y1	Solenoid valve	

Fig. 707: System wiring diagram O405 / O407 / O408, Ident no. 91292



(1) Diagnostic connector

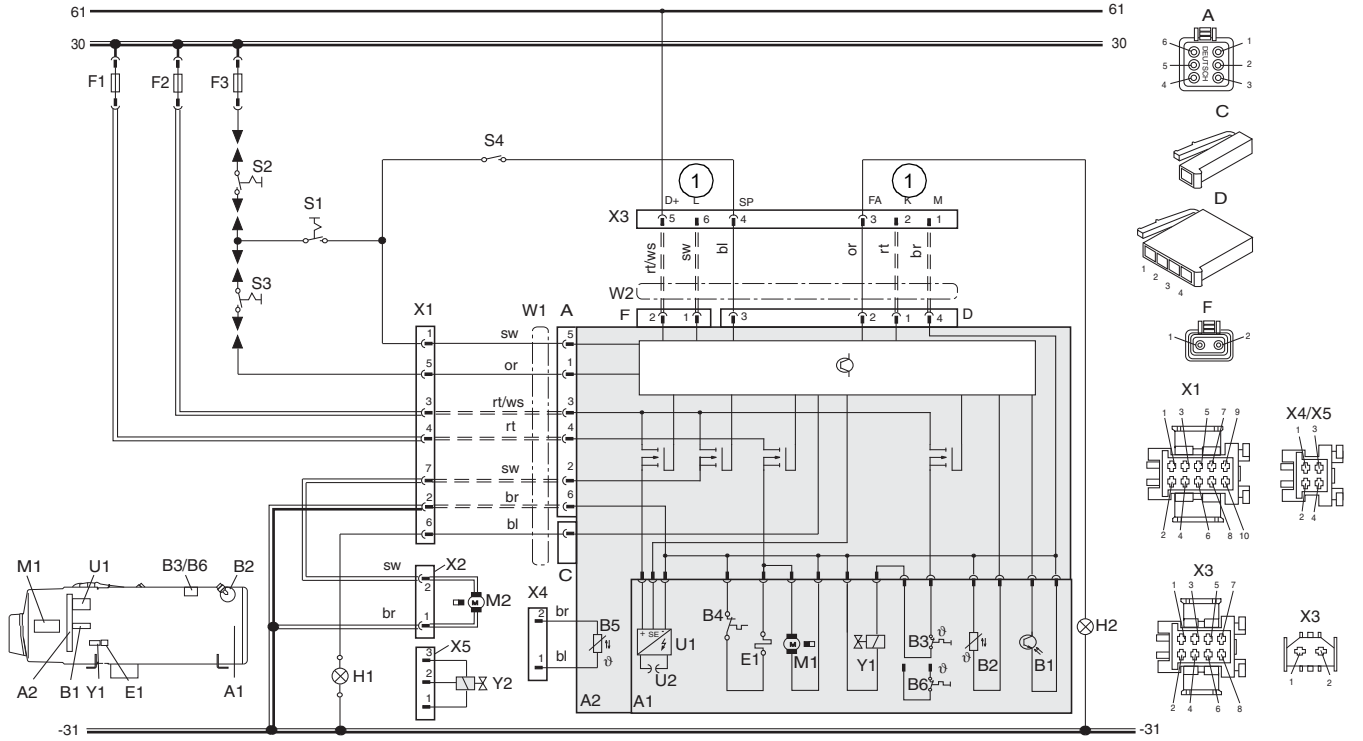
Leitungsfarben	
bl	blau
br	braun
ge	gelb
gn	grün
gr	grau
or	orange
rt	rot
sw	schwarz
vi	violett
ws	weiß

Leitungsquerschnitte		
	< 7,5 m	7,5 - 15 m
	0,75 mm²	1,5 mm²
	1,0 mm²	1,5 mm²
	1,5 mm²	2,5 mm²
	2,5 mm²	4,0 mm²
	4,0 mm²	6,0 mm²

Item	Nomenclature	Remark
A1	Heater	not grounded
A2	Control unit	SG 1572D
B1	Flame sensor	observe polarity
B2	Temperature sensor	polarity optional
B3	Temperature limiter	
B4	Thermostat	for nozzle preheating
E1	Heating cartridge	for nozzle preheating
F2	Fuse 25A	flat fuse acc. DIN 72581 part 3
F3	Fuse 25A	flat fuse acc. DIN 72581 part 3
H1	Light	operation indicator
H2	Light	flame indicator
M1	Motor	combustion air fan
M2	Motor	circulation pump
S1	Switch	on / off
S2	Continuity switch	on water cock
S3	Switch, Ext. pump trigger	required, if S2 does not exist
S4	Switch	power save operation

Item	Nomenclature	Remark
U1	Igniter box	
U2	Igniter electrodes	
W1	Wiring harness (1)	
W2	Wiring harness (2)	
A	Plug connections, 6-pole	
C	Plug connections, 1-pole	
D	Plug connections, 4-pole	
F	Plug connections, 2-pole	
X1	Plug connections, 6-pole	
X2	Plug connections, 2-pole	
X3	Plug connections, 8-pole	
Y1	Solenoid valve	

Fig. 708: System wiring diagram MAN, Ident no. 89404



(1) Diagnostic connector

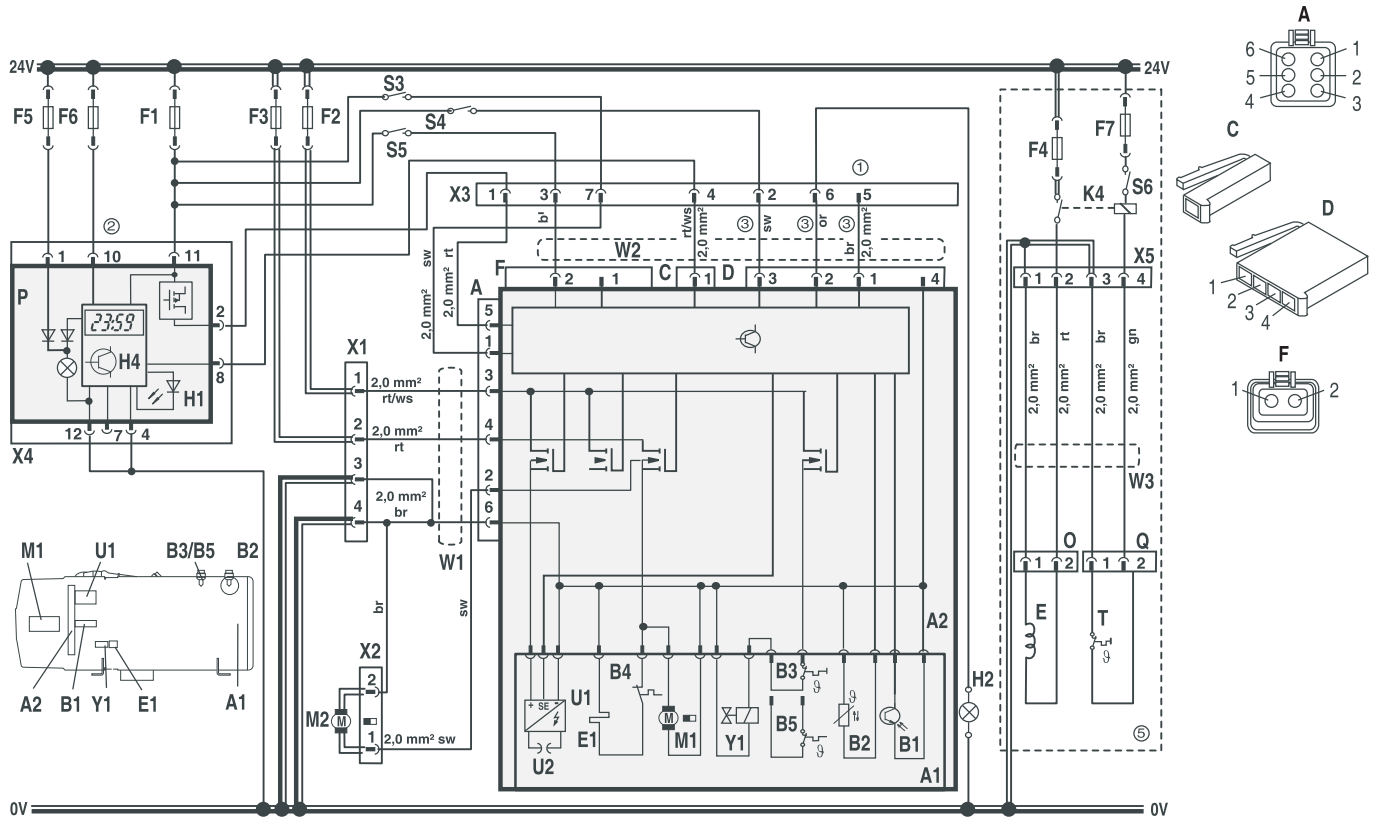
Leitungsquerschnitte		
	< 7,5 m	7,5 - 15 m
	0,75 mm²	1,5 mm²
	1,0 mm²	1,5 mm²
	1,5 mm²	2,5 mm²
	2,5 mm²	4,0 mm²
	4,0 mm²	6,0 mm²

Leitungsfarben	
bl	blau
br	braun
ge	gelb
gn	grün
gr	grau
or	orange
rt	rot
sw	schwarz
vi	violett
ws	weiß

Item	Nomenclature	Remark
A1	Heater	not grounded
A2	Control unit	SG 1572
B1	Flame sensor	observe polarity
B2	Temperature sensor	polarity optional
B3	Temperature limiter	
B4	Thermostat	for nozzle preheating
B5	Temperature sensor, external	observe polarity
B6	Thermostat	alternative to B3
E1	Heating cartridge	for nozzle preheating
F1	Fuse 25A	flat fuse acc. DIN 72581 part 3
F2	Fuse 25A	flat fuse acc. DIN 72581 part 3
F3	Fuse 5A	flat fuse acc. DIN 72581 part 3
H1	Light	operation indicator
H2	Light	flame indicator
M1	Motor	combustion air fan
M2	Motor	circulation pump
S1	Switch	on / off
S2	Continuity switch	on water cock

Item	Nomenclature	Remark
S3	Switch, Ext. pump trigger	required, if S2 does not exist
S4	Switch	power save operation
U1	Igniter box	
U2	Igniter electrodes	
W1	Wiring harness (1)	
W2	Wiring harness (2)	
A	Plug connections, 6-pole	
C	Plug connections, 1-pole	
D	Plug connections, 4-pole	
F	Plug connections, 2-pole	
X1	Plug connections, 10-pole	
X2	Plug connections, 2-pole	
X3	Plug connections, 8-pole	
X4	Plug connections, 4-pole	
X5	Plug connections, 4-pole	
Y1	Solenoid valve	
Y2	Shut-off valve with filter	

Fig. 709: System wiring diagram SETRA, Ident no. 90972



(1) Diagnostic connector

(2) Timer P:
with plus to connection 10 = continuous operating during immediate heating
terminal 10 not connected = duration of heating programmable (10 min to 120 min);

(3) Pin assignment:

Pin assignment	4wire lead	7wire lead
D1	0,75 gr	0,75 rt
D2	0,75 or	0,75 or
D3	0,75 gn	0,75 bl
D4	0,75 br	2,0 br
F1	not used	2,0 sw
F2	not used	2,0 rt/ws

Leitungsquerschnitte

	< 7,5 m	7,5 - 15 m
———	0,75 mm²	1,5 mm²
— — —	1,0 mm²	1,5 mm²
———	1,5 mm²	2,5 mm²
———	2,5 mm²	4,0 mm²
———	4,0 mm²	6,0 mm²

Leitungsfarben

bl	blau
br	braun
ge	gelb
gn	grün
gr	grau
or	orange
rt	rot
sw	schwarz
vi	violett
ws	weiß

(5) Option

Item	Nomenclature	Remark
A1	Heater	not grounded
A2	Control unit	SG 1572
B1	Flame sensor	observe polarity
B2	Temperature sensor	polarity optional
B3	Temperature limiter	
B4	Thermostat	for nozzle preheating
B5	Thermostat	alternative to B3
E	Filter heating	
E1	Heating cartridge	for nozzle preheating
F1	Fuse 5A	flat fuse acc. DIN 72581 part 3
F2	Fuse 25A	flat fuse acc. DIN 72581 part 3
F3	Fuse 25A	flat fuse acc. DIN 72581 part 3
F4	Fuse 25A	flat fuse acc. DIN 72581 part 3
F5	Fuse 5A	flat fuse acc. DIN 72581 part 3
F6	Fuse 5A	flat fuse acc. DIN 72581 part 3
F7	Fuse 5A	flat fuse acc. DIN 72581 part 3
H1	Light	operation indicator
H2	Light	flame indicator
H4	Symb. “Heating“ on display	operation indicator light (in pos. P)
K4	Relay	
M1	Motor	combustion air fan
M2	Motor	circulation pump
P	Pre-selection timer	for pre-selection operation

Item	Nomenclature	Remark
S1	Switch	on / off
S3	Switch	ext. pump trigger
S4	Switch	power save operation
S5	Switch	aux. heating
S6	Switch	filter heating on
T	Temperature switch	filter heating
U1	Igniter box	
U2	Igniter electrodes	
W1	Wiring harness (1)	
W2	Wiring harness (2)	
W3	Wiring harness (3)	
A	Plug connections, 6-pole	
C	Plug connections, 1-pole	
D	Plug connections, 4-pole	
F	Plug connections, 2-pole	
O	Plug connections, 2-pole	
Q	Plug connections, 2-pole	
X1	Plug connections, 4-pole	
X2	Plug connections, 2-pole	
X3	Plug connections,7-pole	
X4	Plug connections, 12-pole	
X5	Plug connections, 4-pole	
Y1	Solenoid valve	

Fig. 710: Automatic Control Circuit Rail with Control Unit 1572D, standard timer and filter heating

8 Servicing

8.1 General

This section describes the servicing procedures allowed on the heater when installed.

8.2 Heater Servicing

As long as the heater is in operation or in run-down the battery main power supply must not be disconnected to prevent the heater from overheating by response of the overheat protection.
When performing long time repairs on the heater its removal is appropriate.
After working on the heating circuit replenish with a coolant mix prepared with water and anti-freeze and bleed circuit afterwards according to manufacturer's instructions.

8.3 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).

8.4 Heater Test Run

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

8.5 Maintenance

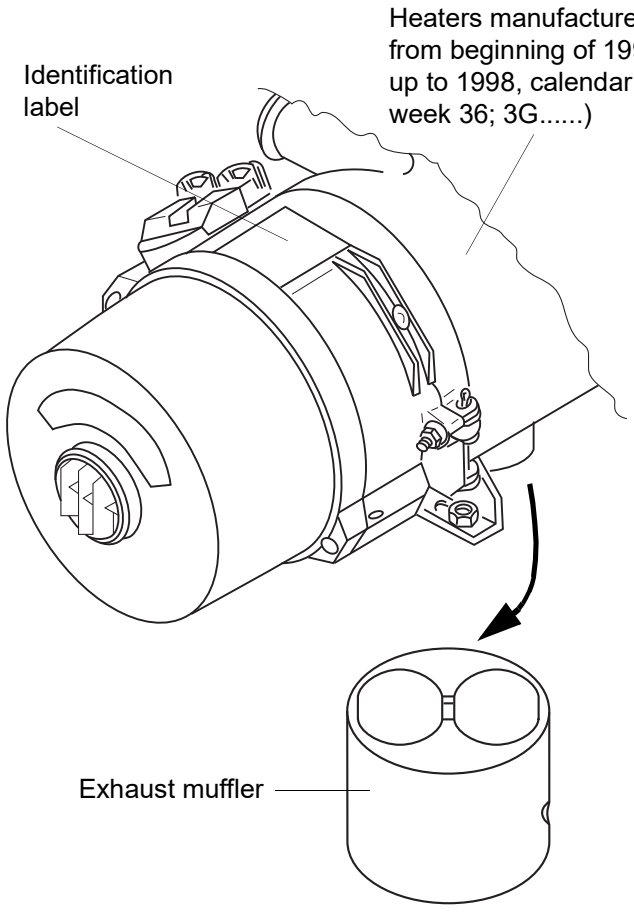
The heater should be inspected in periodic time intervals, latest at the beginning of the heating period (time of increased heater usage due to present weather conditions), refer to Maintenance plan in the Appendix.

8.5.1 Inspection and Attachment of the Exhaust Muffler (only heaters from year of production 1996 and up to production date 1996, calendar week 36; 3G.....)

NOTE:
If the exhaust muffler is already secured with a sheet metal screw, the following procedure need not be performed.

General

The exhaust muffler of heaters manufactured from the beginning of 1996 up to a manufacturing date of 1998 (calendar week 36; 3G.....) (for year or date of production refer to identification label) the exhaust muffler may get loose or lost under certain circumstances. Therefore an inspection for proper attachment of the muffler should be performed.

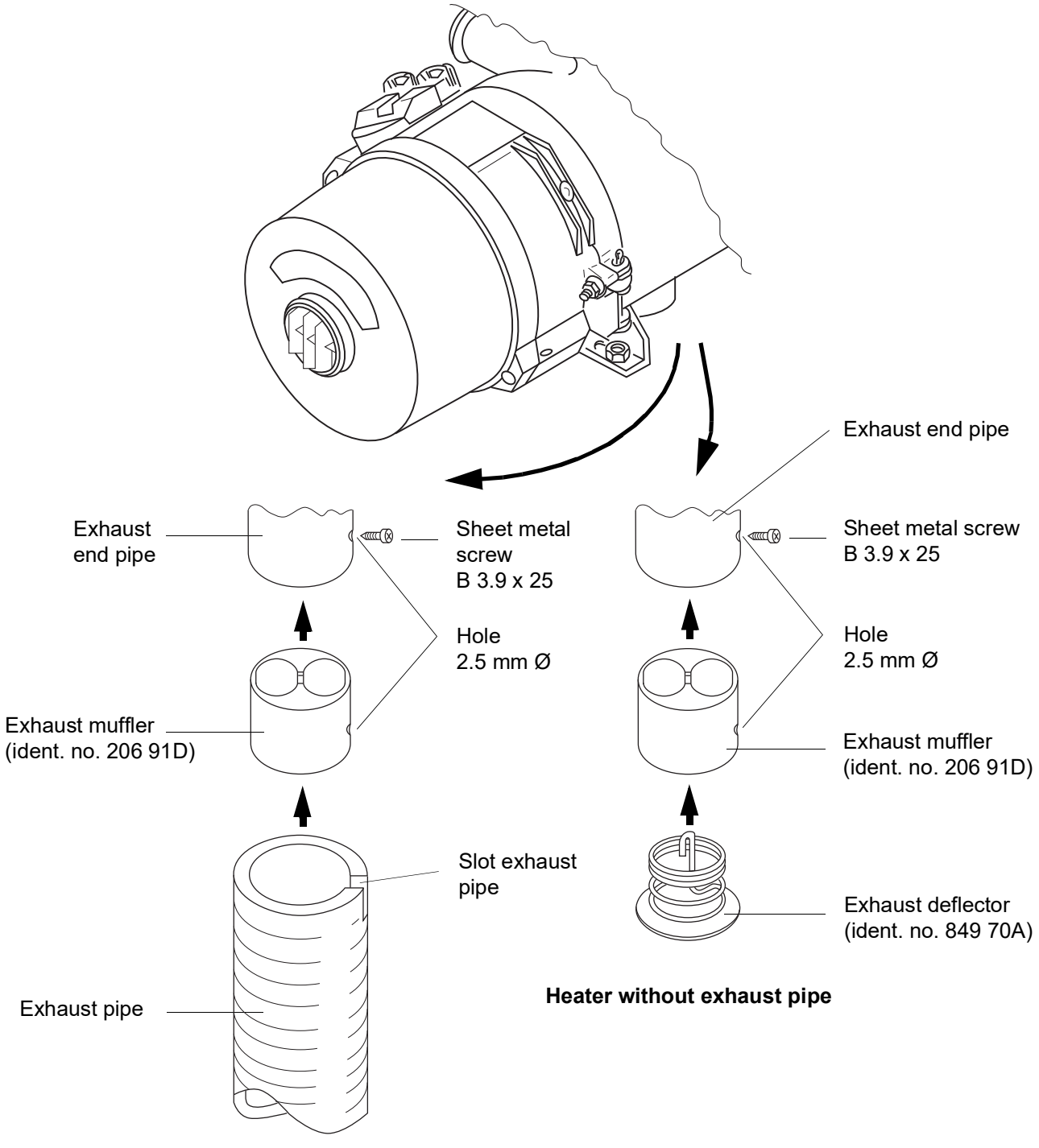


Inspection and Attachment

NOTE:

The exhaust muffler must always be secured with a sheet metal screw. Drill a hole with a diameter of 2.5 mm into the exhaust end pipe and muffler and arrest muffler with a sheet metal screw B 3.9 x 25 (see figure).

1. Check exhaust end pipe for presence of muffler. For checking remove exhaust end pipe as required.
2. If muffler is found in exhaust end pipe fasten as described in NOTE. Slot or drill exhaust end pipe and refit.
3. If no muffler is found in exhaust end pipe check if muffler is upstream in exhaust pipe. If muffler is dislocated in the exhaust pipe, arrest muffler as described in NOTE. Slot or drill exhaust pipe and refit.
4. If the exhaust muffler has been lost it may be ordered from Spheros (ident. no. 20691_). Fasten muffler according to NOTE. Slot or drill exhaust pipe and refit.
5. If heater is operated without exhaust pipe, fasten muffler according to NOTE. An exhaust deflector must be additionally fitted.



8.5.2 Burner Head Opening and Closing

Warning!	High voltage! Danger to life!

The igniter box operates with high voltage. Prior to opening the burner head the connectors of the cable harness in the vehicle have to be disconnected to prevent lethal injuries.
After closing burner head, reconnect connectors in the vehicle.

NOTE:
Maintenance on the heater is easy. By swinging the burner head open the following components become accessible:
– fuel pump and fuel nozzle
– solenoid valve
– igniter box
– igniter electrodes
– flame sensor
– combustion chamber
– nozzle block preheater (if installed)

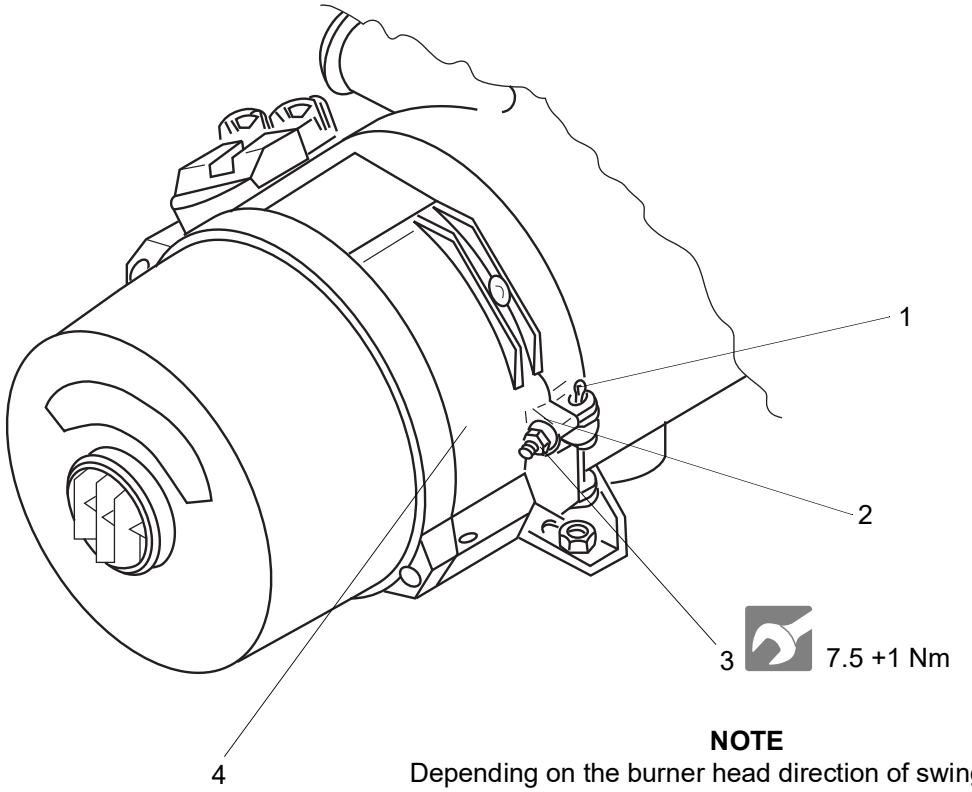
In order to obtain a convenient burner head opening angle it is required to disconnect the electrical connection(s) to the temperature limiter and temperature sensor.

Opening
1. Disconnect electrical connections to temperature limiter and temperature sensor.
2. Loosen nuts (3, Fig. 801) enough to release hinge bolts (2).
3. Swing hinge bolts (2) outwards.
4. Swing burner head (4) away.

Closing
1. If required engage burner head (4, Fig. 801) into the hinge and secure it using the cotter pin (1).
2. Swing burner head (4) into closed position.
3. Swing hinge bolts (2) into lock position and secure with nuts (3).
4. Tighten nuts (3).
5. Reconnect electrical connections to the temperature limiter and temperature sensor.

NOTE
When making electrical connections observe wiring color codes.

1 Cotter pin
2 Screw (2)
3 Nut (2)
4 Burner head



NOTE
Depending on the burner head direction of swing the cotter pin may be located on the opposite side.

Fig. 801 Swinging Burner Head open

8.6 Visual Inspections and Regulations for Installation

8.6.1 Connection to Vehicle Cooling System

The installation of the heater should be in a location as low as possible to ensure self-venting of the heater and circulation pump. This applies in particular for the circulation pump because it is not self-sucking.

The heater is to be connected to the vehicle cooling system according to Fig. 802. The cooling system coolant capacity must be at least 10 liters.

The vehicle cooling system or the separate heating circuit must use only pressure relief valves with an opening pressure of at least 0.4 bar and of max. 2.0 bar.

It is a basic requirement to use the coolant hoses supplied by Spheros, otherwise the hoses must at least meet the specifications of DIN 73411. The hoses have to be installed free of kinks and for proper venting in an inclination. Hose connections must be secured against slippage with hose clamps.

NOTE:
The specified tightening torques of the hose clamps used must be complied with.

Prior to the heater's first operation or after replacement of the coolant, attention must be paid to carefully bleed the cooling system. Heater and lines must be installed so that static venting is guaranteed.

Improper venting may cause malfunctions by overheating in equipment operation.

Proper venting may be identified by a circulation pump almost noiseless in operation.

When using the circulation pump Aquavent 6000 (U4851) or Aquavent 6000S (U4852) or Aquavent 6000SC (U4856) the circulation pump automatically is switched off approx. 15 seconds after switch-on if coolant is lacking or the pump wheel is jammed.

In combination with control unit 1572D (Thermo label colored) and with programmed circulation pump check the heater also switches off when coolant is missing.

8.6.2 Connection to Vehicle Fuel System

Fuel is tapped from the fuel reservoir of the vehicle or from a separate fuel tank.

8.6.2.1 Fuel Lines

In order to avoid air from being captured in fuel lines, they should only be installed with an incline. The fuel line joints are to be secured against slipping with hose clamps should no screwed mechanical unions be in use.

Should fuel hoses be installed always use the hoses supplied or offered by Spheros. If other hoses are used they must at least meet the specifications of DIN 73379. Fuel hoses must not be kinked or twisted and must be secured with clamps every 25 cm.

For routing fuel also fuel lines may be used consisting of materials standard in the manufacturing of vehicles, e.g. steel, copper or plastic lines made of unhardened, light and temperature stabilized PA11 or PA12 (e.g. Mecanyl RWTL) according to DIN 73378 observing the applicable jointing instructions.

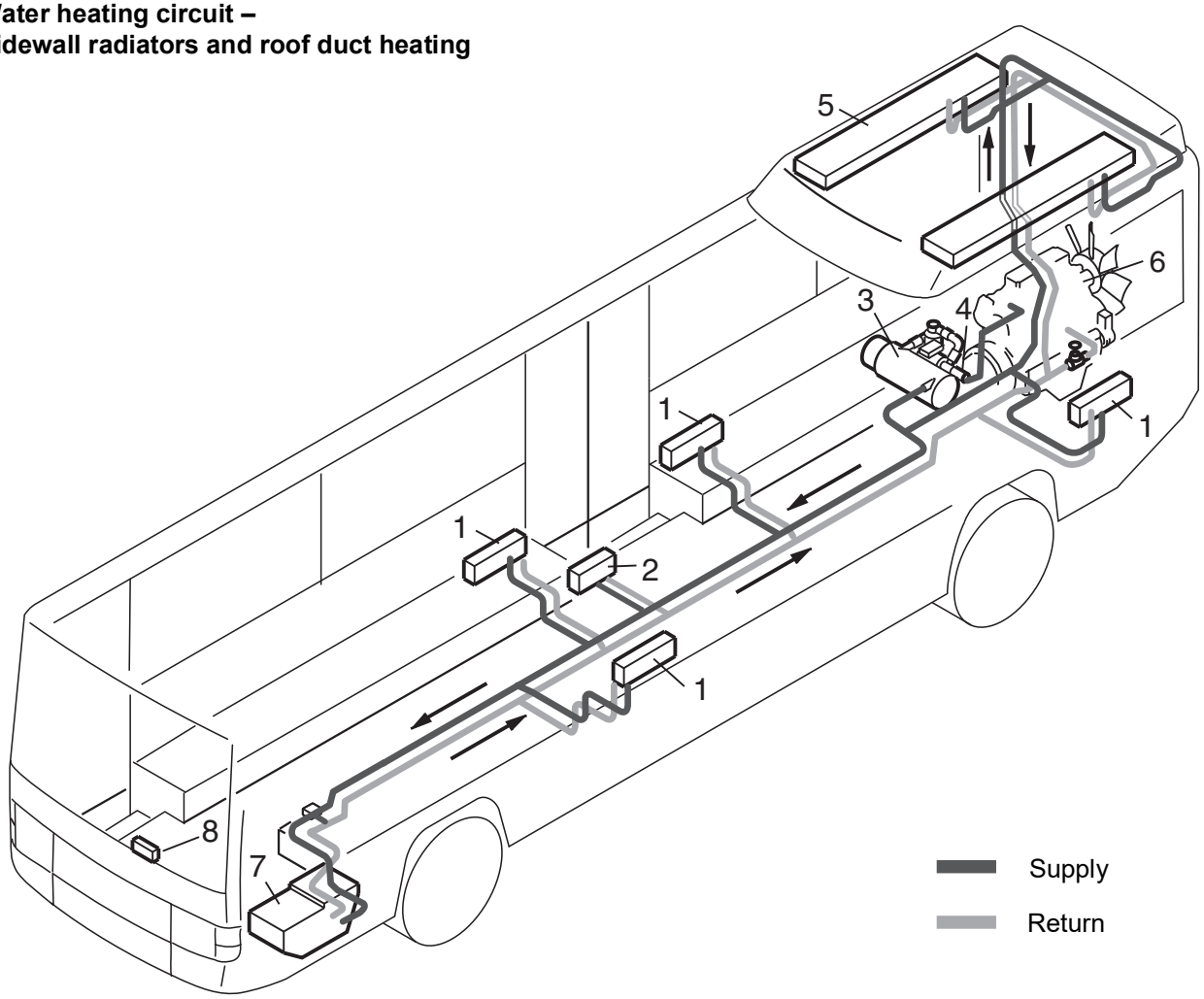
Basic rules for the routing of fuel lines are:
- Protect against undue temperatures.

ATTENTION:

In overheat condition the heater outer shell may reach Diesel fuel inflammation temperature!

- **Protect lines from stone strike.**
- **Dripping or evaporating fuel may neither accumulate nor ignite on hot components or electrical equipment.**

Water heating circuit –
Sidewall radiators and roof duct heating



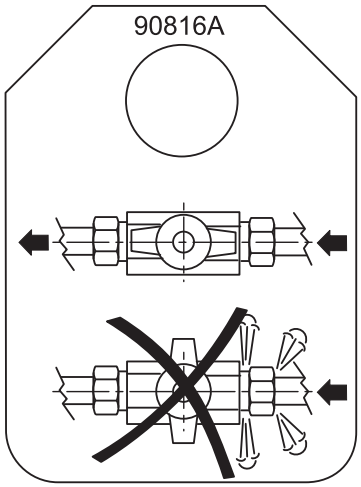
1 Sidewall radiator with fan
2 Heat exchanger, entrance
3 Heater unit
4 Circulation pump
5 Heat exchanger, roof
6 Vehicle engine
7 Cockpit heating
8 Control element

Fig. 802 Example of a Heater Installation in a Passenger Bus

When installing a shut-off device in the return line a clearly visible information label must be provided.

ATTENTION:

Operation with the return line shut off causes damage to the fuel pump. Fuel may escape. Danger of fire.



Information label

Loose fuel lines must be secured in order to avoid sagging.

The installation of an additional fuel pump is not allowed.

Fuel lines permissible dimensions:
- inner diameter for suction and return line:
- 6 mm (other diameters upon request).
- max. permissible length for each suction and return line: 10 m
- Max. permissible suction height: 2 m
- Max. permissible priming pressure: 0.3 bar for suction and return line.

8.6.2.2 Fuel Filter

A by Spheros supplied with or approved fuel filter is to be installed. Installation position possibly vertical with horizontal direction of flow.
To avoid operating malfunctions replace filter or filter cartridge once a year or more often if fuel is contaminated.

8.6.3 Combustion Air Supply

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

Observe official regulations concerning the installation (see 1.6).
Combustion air must under no circumstances be extracted from rooms with persons.

ATTENTION:

The combustion air inlet must not point towards the forward direction of motion.
It must be located so that no clogging by contamination, impact of snow, or intake of splash water is to be expected.

The combustion air intake and exhaust outlet is to be located so that no air pressure difference builds up in any operating condition of the vehicle.

Permissible dimensions of combustion air intake line:
- inner diameter: 55 mm
- max. length: 5 m
- max. bend: 270°

The combustion air inlet must be located so that no exhaust fumes can enter.

NOTE:
If the combustion air intake line cannot be routed upwards, a water drain hole Ø 4 mm is to be provided at the lowest point.

If the heater is located near the fuel tank in a common installation compartment, combustion air must be taken in from and the exhaust routed to the exterior. The feed-throughs must be sealed against splash water.

If the heater is located in a closed installation box, a vent port is required:

Thermo 230 and *300*	30 cm^2
Thermo 350	35 cm^2

If the temperature in the installation box exceeds the permitted ambient temperature of the heater (see Technical Data), the vent port must be enlarged consulting Spheros.

8.6.4 Exhaust Line

Warning!	Danger to life and health!

Observe official regulations concerning the installation (see 1.6).

ATTENTION:

The exhaust pipe outlet opening must not point in the direction of motion.

The exhaust pipe outlet opening must be located so as not to expect clogging by snow or mud.

The combustion air intake and exhaust outlet is to be located so that no air pressure difference builds up in any operating condition of the vehicle.

Rigid pipes made of unalloyed or alloyed steel with a minimum wall thickness of 1.0 mm have to be used as exhaust line or flexible pipes made of alloyed steel only. The exhaust pipe is secured to the air heater e.g. with a clamp.

Permissible exhaust line dimensions:
– inner diameter: 70 mm
– max. length: 5 m without combustion air intake extension line
– max. bend: 270°

As an alternative an exhaust deflector must be installed approved by Spheros.

8.7 Removal and Installation

CAUTION
In installed condition only the following disassembly or removal procedures are permitted should enough space for removal allow such action:

– replacement of temperature limiter
– replacement of temperature sensor
– replacement of combustion air fan
– replacement of burner
– replacement of igniter box
– replacement of flame sensor
– replacement of combustion chamber

8.7.1 Heater, Removal and Installation

8.7.1.1 Removal

1. Disconnect connectors of cable harness in vehicle and of circulation pump.
2. Disconnect combustion air intake on heater if required.
3. Loosen clamp on exhaust outlet.
4. Loosen fuel supply and return line connections, disconnect and fit dummy plugs.
   Close water cocks as applicable.
5. Loosen hose clamps on coolant hoses, disconnect hoses and fit dummy plugs.
6. Remove 3 screws and washers or 4 screws and washers.
7. Remove heater.

8.7.1.2 Installation

1. Locate heater for installation and secure with 3 screws and washers or 4 screws and washers.
2. Secure line on exhaust outlet using clamp.
3. Slide on coolant hoses and fasten with hose clamps. Torque clamps with 1.5 Nm. Open water cocks.
4. Connect fuel supply and return lines and tighten connections.
5. Secure combustion air inlet line on heater as applicable.
6. Connect electrical connectors of cable harness in vehicle and to circulation pump.
7. Bleed fuel supply system.
8. Bleed coolant circuit.

8.7.2 Temperature Limiter, Replacement

NOTE:
The replacement procedure for the temperature limiter is identical with the heater installed or removed.
Perform replacement in accordance with 9.2.1.

8.7.3 Temperature Sensor, Replacement

NOTE:
The replacement procedure for the temperature sensor is identical with the heater installed or removed.
Perform replacement in accordance with 9.2.2.

Caution!	Risk of scalding!

Prior to replacement of temperature sensor in installed condition relief overpressure in cooling system by opening the cooling circuit sealing element.

If required also allow heater to cool down and have collector vessel ready to collect escaping coolant.

8.7.4 Burner, Replacement

NOTE:
The replacement procedure for the burner is identical with the heater installed or removed.
Perform replacement in accordance with 9.2.3.

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

The igniter box operates on high voltage. Prior to replacement of burner disconnect electrical connectors of cable harness in vehicle to avoid lethal accidents.

8.7.5 Igniter Box, Replacement

NOTE:
The replacement procedure for the igniter box is identical with the heater installed or removed.
Perform replacement in accordance with 9.2.8.

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

The igniter box operates on high voltage. Prior to replacement of burner disconnect electrical connectors of cable harness in vehicle to avoid lethal accidents.

8.7.6 Flame Sensor, Replacement

NOTE:
The replacement procedure for the flame sensor is identical with the heater installed or removed.
Perform replacement in accordance with 9.2.9.

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

The igniter box operates on high voltage. Prior to replacement of burner disconnect electrical connectors of cable harness in vehicle to avoid lethal accidents.

8.7.7 Combustion Chamber, Replacement

NOTE:
The replacement procedure for the combustion chamber is identical with the heater installed or removed.
Perform replacement in accordance with 9.2.11.

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

The igniter box operates on high voltage. Prior to replacement of burner disconnect electrical connectors of cable harness in vehicle to avoid lethal accidents.

8.8 First Operation

After heater installation the coolant circuit and the fuel supply system must be thoroughly bled observing the vehicle manufacturer's instructions. During test runs all coolant and fuel line connections have to be checked for security and no leakage. Should the heater in operation enter a fault condition, perform troubleshooting (refer to Section 5).

NOTE:
Heaters with control unit 1572D:
If the heater performs 5 subsequent attempts to start due to a malfunction, the heater enters an error lockout and stops any further attempts to start. This error lockout is superior to the normal error lockout condition.
The error lockout reset is achieved by switching the heater on and disconnection of the heater power supply within 120 sec. during run-down.

8.8.1 Water Circuit, Bleeding

NOTE:
Bleeding must always be performed in accordance with manufacturer's instructions. For bleeding the circulation pump must not be switched on.

Set vehicle own heating system to "warm" and replenish coolant which must consist of at least 30 % anti-freeze (on glycol base) (protection against corrosion). When using pure water there will be no protection against corrosion and due to the lower boiling point of the water when overheating loss of cooling water may result requiring continuous replenishment. Additives in the coolant must not affect metals, plastics or rubber and leave no deposits.

Then operate engine at increased idle until radiator thermostat opens. Shut down engine, check coolant level and replenish as required.

Switch on heater and vehicle heating fan with engine shut down. After a certain cool-down period the heater must automatically switch on and control to off. In case of no restart attempt the temperature limiter on the heater has responded because the heater has not been bled properly. Reset temperature limiter (push button on temperature limiter) and repeat complete bleeding procedure.

NOTE:
The heater may be equipped with an automatically resetting temperature limiter. The manual reset is not necessary.

8.8.2 Fuel Supply System, Bleeding

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!

9 Repair

9.1 General

This section describes the repairs that may be performed on the heaters *Thermo 230, 300* and *350* when removed. Any further disassembly will void the warranty.
For re-assembly only components of the proper spare part kits are to be used.

The following components may also be replaced with the heater installed unless restricted space prevents access:

– temperature limiter
– temperature sensor
– combustion air fan
– burner
– igniter box
– flame sensor
– combustion chamber

NOTE:

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.

9.1.1 Work on Components after Disassembly

ATTENTION:

All gaskets located between disassembled components must always be replaced and discarded.

9.1.1.1 Visual Inspection, General

- Examine all components for damages (cracks, deformation, wear, etc.) and replace as necessary.
- Examine connectors and wiring for corrosion, loose contacts, wrong crimping, etc. and repair as necessary.
- Check terminals for corrosion and contacts for security. Repair as required.

9.1.1.2 Combustion Chamber, Visual Inspection

– Check swirl ring for security.
– Inspect combustion chamber for oxidizing and coke deposits and remove as required.
– Check welding seem for cracks.

NOTE:

Longitudinal cracks up to 80 mm are allowed.

9.1.1.3 Heat Exchanger, Visual Inspection

– Inspect exhaust ducting in heat exchanger for sooting, deposits, damage and corrosion.

NOTE:

Deposits are to be removed with water jet and brush.

– Inspect heat exchanger for exterior damage, deformation, etc.

NOTE:

Heavy deformation may cause restricted flow of coolant.

ATTENTION:

When replacing the combustion chamber, remove deposits in heat exchanger using a suitable tool.

9.1.1.4 Combustion Air Fan Wheel, Visual Inspection

– Check fan wheel for contamination and cracks.
– Check cover plate for security.
– Check slide lock for proper sealing.

9.1.2 Incorporation of Modifications

NOTE:

Continuous enhancement of heater design is for optimizing performance and avoiding failures and malfunctions. Normally equipment in use may be retrofitted using available modification kits.

The following modifications may be incorporated during repair procedures:

- installation of control unit 1572D as substitute for control unit 1572 (see 9.1.2.1).
- Installation of the dust protection for the flame guard (see 9.1.2.2).

9.1.2.1 Installation of Control Unit 1572D as Substitute for Control Unit 1572

General

Due to the progress in the development of processors control unit 1572 can no longer be supplied.
The retrofit of control unit 1572D is performed according to the following procedure:

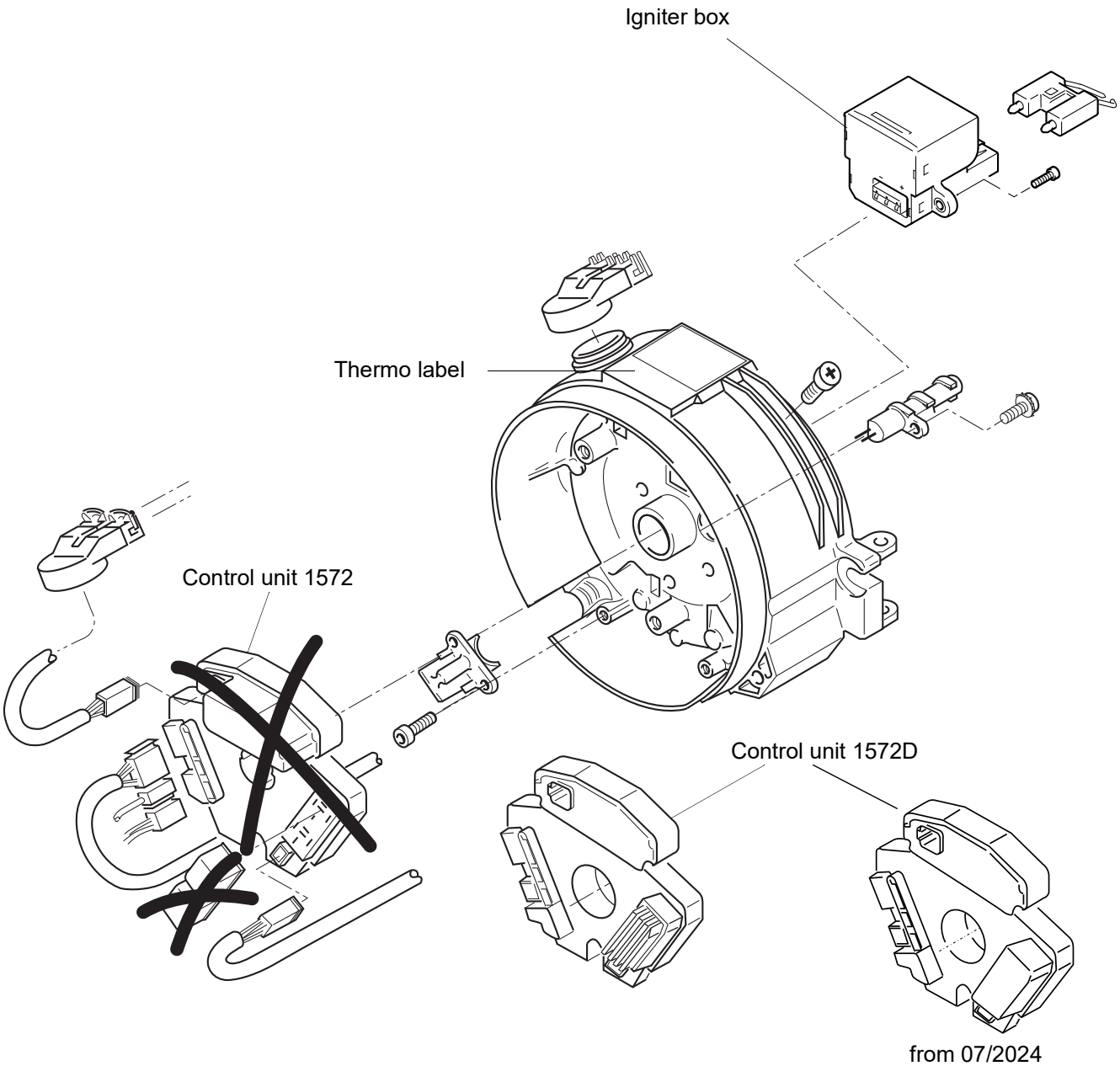
The modification kit consists of:
- control unit 1572D
- igniter box
- thermo identification label

Procedure

ATTENTION:

Control unit 1572D may only be used in combination with the igniter box delivered (green connector cover). The electrical connector is coded.

1. Remove control unit according to 9.2.5.1 and discard.
2. Remove igniter box according to 9.2.8.1 and discard.
3. Install new igniter box according to 9.2.8.2.
4. Install new control unit according to 9.2.5.2.
5. Apply new thermo label onto existing label to indicate retrofit.



9.2 Disassembly and Assembly

9.2.1 Temperature Limiter, Replacement

9.2.1.1 Removal

1. Disconnect electrical connection to temperature limiter.
2. Withdraw rubber cap. Using screw driver lever off retaining spring and remove temperature limiter (1, Fig. 901).

9.2.1.2 Installation

1. Slide rubber cap of temperature limiter (1, Fig. 901) back until temperature limiter can be located for installation.
2. Position temperature limiter (1) in connector (3) and push in retaining clip.

ATTENTION:

The retaining spring must be located in the groove of the housing and must be latched in position both perceptibly and audibly (twice) at the collar of the locating socket. Only then will the temperature limiter be in proper contact with the heat exchanger jacket.

3. After the rubber cap has been placed in position, the cable must be aligned in the cable sleeve, free from strain.
   Connection cables must not be routed over reset button.

NOTE:

Observe electrical wiring color coding when making connections to temperature limiter.

4. Make electrical connections.

9.2.2 Temperature Sensor, Replacement

9.2.2.1 Removal

1. Disconnect electrical connection to temperature sensor.

Caution!	**Risk of scalding!**

Prior to replacement of temperature sensor in installed condition relief overpressure in cooling system by opening the cooling circuit sealing element.

If required also allow heater to cool down and have collector vessel ready to collect escaping coolant.

2. Unscrew temperature sensor (2, Fig. 1) and remove.

9.2.2.2 Installation

1. Manually screw temperature sensor (2, Fig. 1) into coolant outlet (4).
2. Tighten temperature sensor.
3. Restore electrical connections.

NOTE:

Observe electrical wiring color coding when making connections to temperature sensor.

9.2.3 Burner, Replacement

9.2.3.1 Removal

1. Disconnect electrical connections on burner and loosen fuel lines.
2. Loosen nuts (6, Fig. 1) until hinge bolts are free.
3. Swing hinge bolts (7) open and remove cotter pin (5).
4. Remove burner (8).
5. Perform procedures on components after disassembly (refer to 9.1.1).

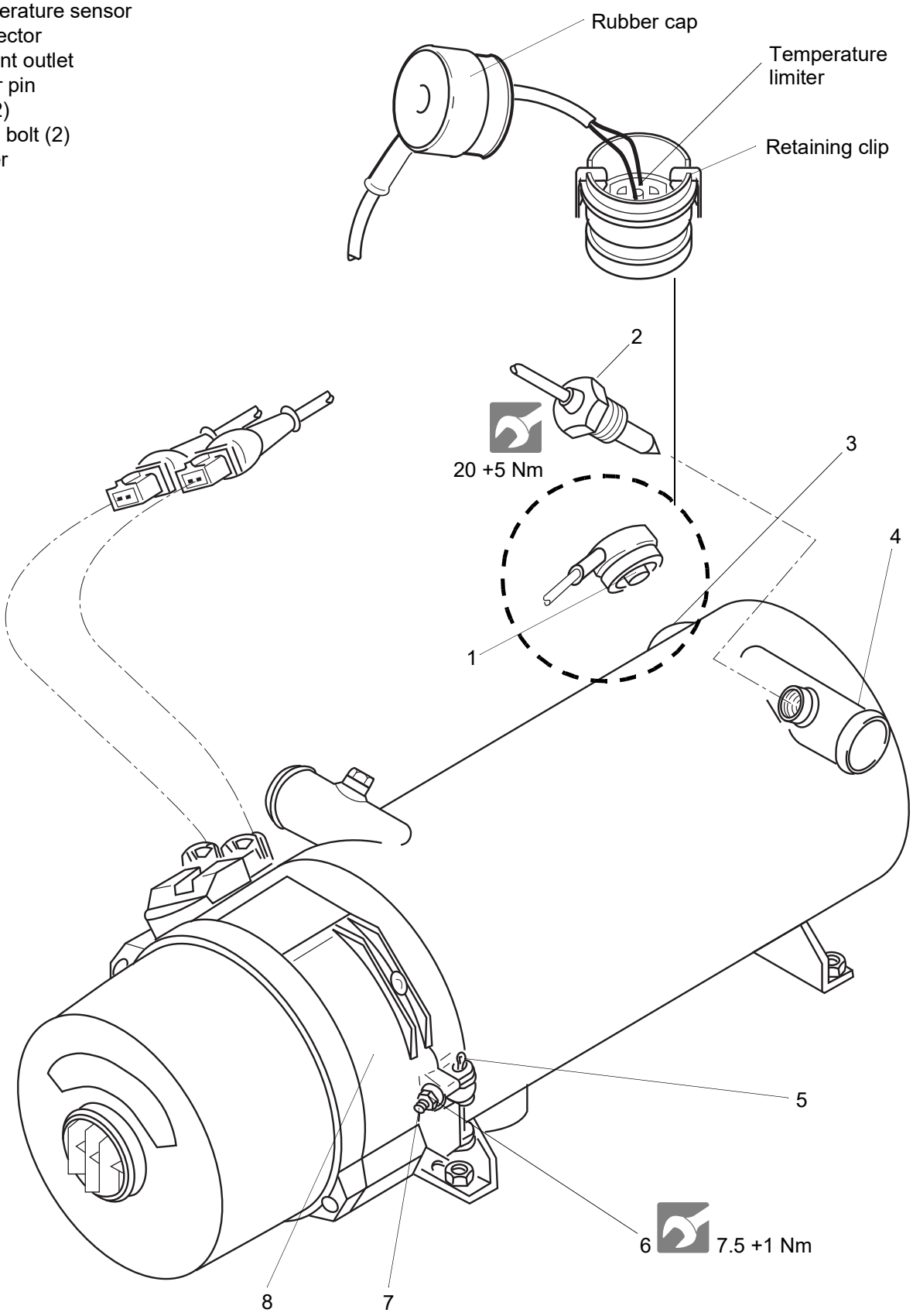
9.2.3.2 Installation

1. Position burner (8, Fig. 1) for installation, swing hinge bolts closed and secure temporarily using screws (6).
2. Insert cotter pin (5) according to the intended opening swing direction.
3. Tighten nuts (6).
4. Connect fuel lines.
5. Restore electrical connections.

NOTE

Observe electrical wiring color coding when making connections to temperature limiter and temperature sensor.

1 Temperature limiter
2 Temperature sensor
3 Connector
4 Coolant outlet
5 Cotter pin
6 Nut (2)
7 Hinge bolt (2)
8 Burner



NOTE
Cotter pin (5) may be fitted on other side as required for burner head to swing open in opposite direction.

Fig. 1 Temperature Limiter, Temperature Sensor and Burner, Replacement

9.2.4 Combustion Air Fan, Replacement

NOTE:

For replacement of the combustion air fan the burner may be left installed.
In removed condition ensure that igniter electrodes are not bent and nozzle is not damaged.

9.2.4.1 Removal

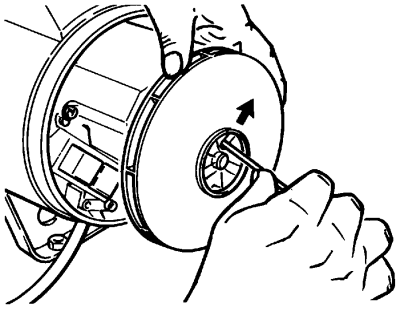
1. Loosen screws (3, Fig. 2) and withdraw cap (2) from burner.
2. Using suitable tool (e.g. mandrel 3 mm) open slide lock (5) until fan wheel can be pulled off.
3. Disconnect electrical connector (9).
4. Remove screws (6) with lock washers and withdraw fan motor (7).
5. Perform procedures on components after disassembly (refer to 9.1.1).

9.2.4.2 Installation

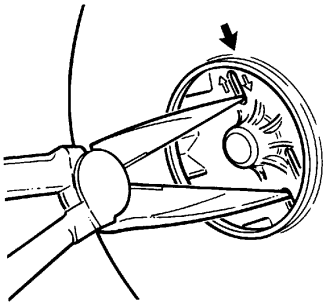
NOTE:

Fan motor (7, Fig. 2) to be aligned with control unit (recess in mounting flange) and with clutch (by rotating drive shaft).

1. Align fan motor (7) and position for installation.
2. Attach fan motor using screws (6) and lock washers.
3. Tighten screws.
4. Connect electrical connector (9).
5. Bring slide lock (5) on fan wheel in installation position.
6. Slide fan wheel onto drive shaft and using suitable tool (e.g. mandrel 3 mm or pliers) close slide lock until fan wheel is locked.
7. Locate cap (2) and secure with screws (3).
8. Tighten screws.



Opening slide lock



Closing slide lock

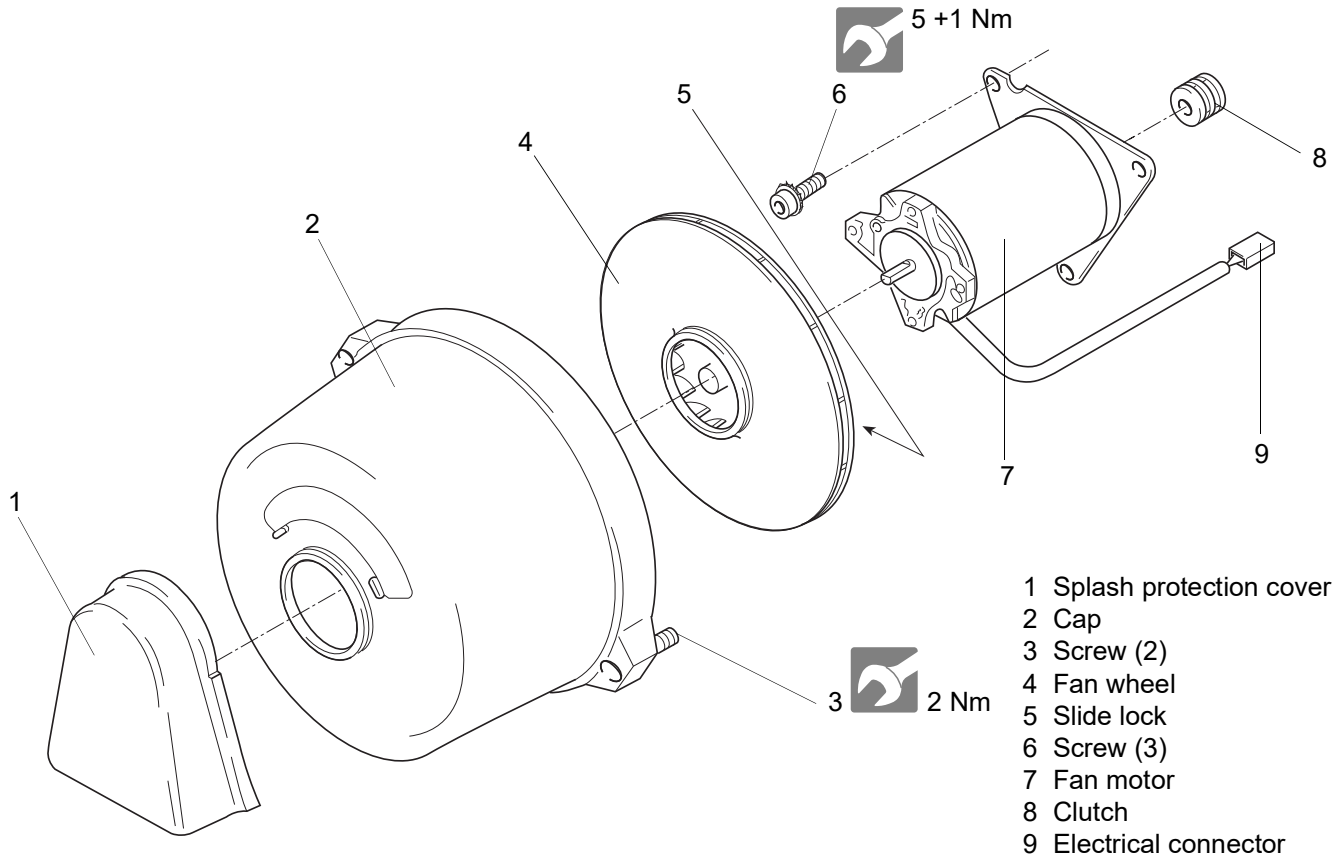


Fig. 2 Combustion Air Fan, Replacement

9.2.5 Control Unit, Replacement

NOTE:
For replacement of the control unit the burner head may be left installed and must only be swung open for disconnection of electrical connector (8, Fig. 904).
In removed condition ensure that igniter electrodes are not bent and nozzle is not damaged.
If a control unit 1572 is substituted with a control unit 1572D, perform procedure according to 9.1.2.1.

9.2.5.1 Removal

1. Disconnect all electrical connections from control unit (23, Fig. 904).
2. Swing burner head open (refer to) and disconnect electrical connector (8).
3. Remove flame sensor (refer to 9.2.9.1).
4. Remove combustion air fan (refer to 9.2.4.1).
5. Carefully withdraw control unit (23) in axial direction from burner head (17) and remove.
6. Perform procedures on components after disassembly (refer to 9.1.1).

9.2.5.2 Installation

1. Carefully push control unit (23, Fig. 904) in axial direction against stop into burner head (17).
2. Install combustion air fan (refer to 9.2.4.2).
3. Make all electrical connections on control unit (23).
4. Install flame sensor (refer to 9.2.9.2).
5. Connect electrical connector (8).

9.2.6 Fuel Pump, Replacement

9.2.6.1 Removal

1. Remove burner (refer to 9.2.3.1).
2. Using screwdriver lever off igniter electrodes (3, Fig. 904) from igniter box (1) and remove.
3. Remove disc (6) with heating cartridge (if installed).
4. Disconnect electrical connector (8).

NOTE:
During the following step ensure that escaping fuel is immediately neutralized and properly disposed of.

5. Remove screws (9) and discard.
6. Withdraw fuel pump (10) together with solenoid valve (7) and remove.
7. Remove and discard O-rings (12) and filter screen (11).
8. Remove solenoid valve (7) from fuel pump (10) as required.
9. Perform procedures on components after disassembly (refer to 9.1.1).

9.2.6.2 Installation

1. Install solenoid valve (7, Fig. 904) on fuel pump (10) if required.
2. Fit new O-rings (12) and filter screen (11) on fuel pump (10).
3. Position fuel pump (10) for installation and secure with new screws (9) (with threadlock coating).
4. Tighten screws.
5. Connect electrical connector (8).
6. Plug on disk (6) and mount heating cartridge.
7. Plug on igniter electrodes (3).
8. Install burner (refer to 9.2.3.2).

9.2.7 High Pressure Nozzle, Replacement

9.2.7.1 Removal

1. Remove burner (refer to 9.2.3.1).
2. Using screwdriver lever off igniter electrodes (3, Fig. 904) from igniter box (1) and remove.
3. Remove disk (6) with heating cartridge (if installed).
4. Disconnect electrical connector (8) of the heating cartridge.
5. Unscrew high pressure nozzle (4).

NOTE:
Ensure cleanliness is maintained when installing the nozzle. Only touch the nozzle at its hexagon surface.

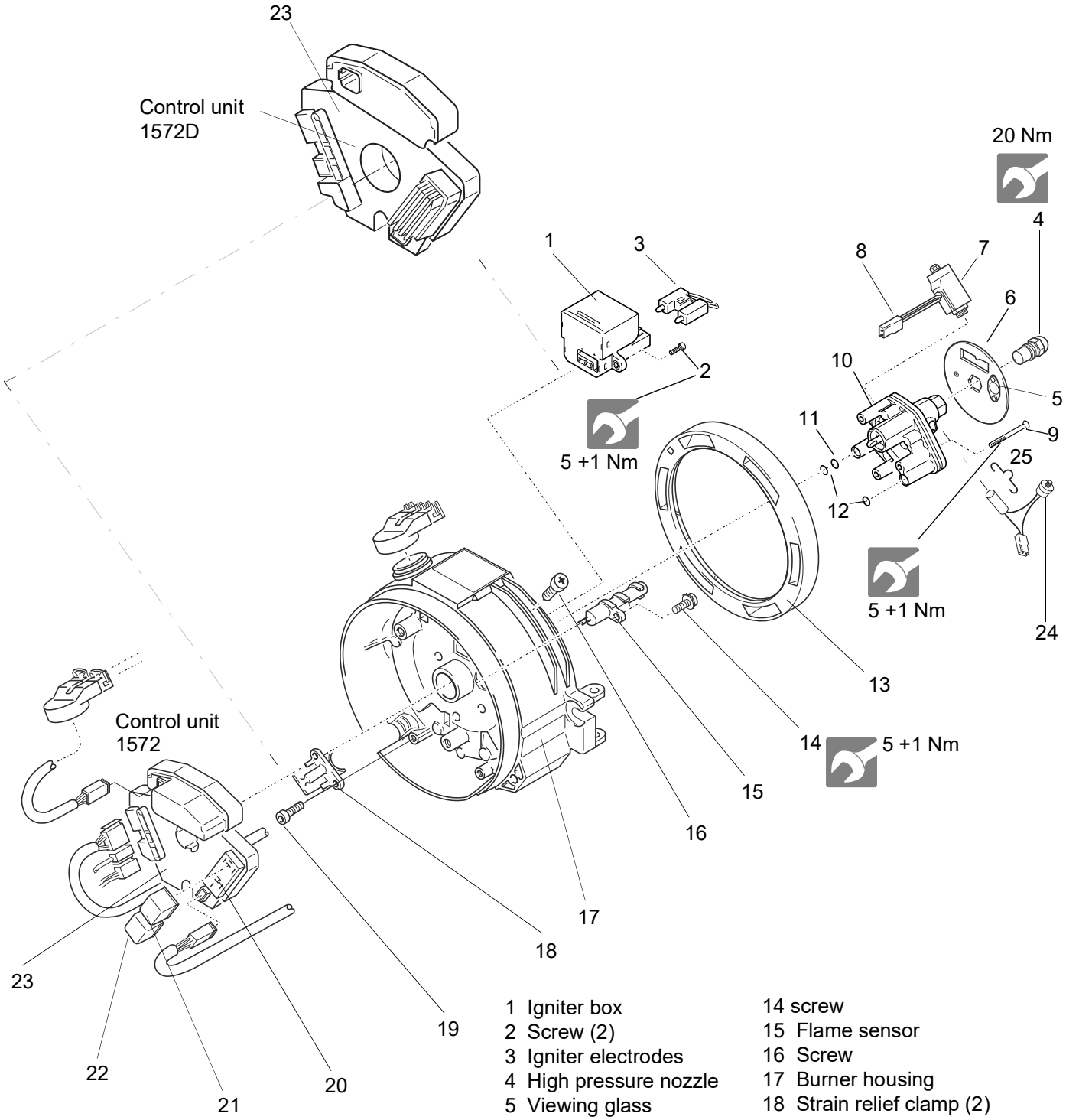
9.2.7.2 Installation

1. Screw in high pressure nozzle (4, Fig. 904) and tighten.
2. Connect electrical connector (8) of the heating cartridge.
3. Plug on disk (6) and mount heating cartridge.
4. Plug on igniter electrodes (3).
5. Install burner (refer to 9.2.3.2).

9.2.8 Igniter Box, Replacement

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

The igniter box operates with high voltage. Prior to opening the burner head the connectors of the cable harness in the vehicle have to be disconnected to prevent lethal injuries.



1 Igniter box
2 Screw (2)
3 Igniter electrodes
4 High pressure nozzle
5 Viewing glass
6 Disk
7 Solenoid valve
8 Electrical connector
9 Screw (3)
10 Fuel pump
11 Filter screen
12 O-ring (2)
13 Rotating ring
14 screw
15 Flame sensor
16 Screw
17 Burner housing
18 Strain relief clamp (2)
19 Screw (2)
20 Base plate
21 Relay
22 Relay
23 Control unit
24 Heating cartridge with thermostat
25 Clip

Fig. 3 Control Unit and Fuel Pump, Replacement

9.2.8.1 Removal

1. Remove burner if required (refer to 9.2.3.1).
2. Using screw driver lever off igniter electrodes (Fig. 4) from igniter box and remove.
3. Remove disk (6).
4. Remove combination screws (2).
5. Withdraw igniter box (1) and remove.
6. Perform procedures on components after disassembly (refer to 9.1.1).

9.2.8.2 Installation

1. Locate igniter box (1, Fig. 4) for installation, plug on making correct electrical connections and secure with combination screws (2).
2. Tighten combination screws (2).
3. Plug on disk (6) and align.
4. Plug on igniter electrodes (3).
5. Install burner (refer to 9.2.3.2).

9.2.9 Flame Sensor, Replacement

9.2.9.1 Removal

1. Remove burner if required (refer to 9.2.3.1).
2. If required lever off igniter electrodes (Fig. 904) from igniter box using screw driver and remove.
3. Remove disk (6).
4. Remove screw (14) and lock washer.
5. Withdraw flame sensor (15) and remove.
6. Perform procedures on components after disassembly (refer to 9.1.1).

9.2.9.2 Installation

1. Position flame sensor (15, Fig. 4) for installation, plug on to make correct electrical connections and secure with screw (14) and lock washer.
2. Tighten screw (14).
3. Plug on disk (6) and align.
4. Plug on igniter electrodes (3).
5. Install burner (refer to 9.2.3.2).

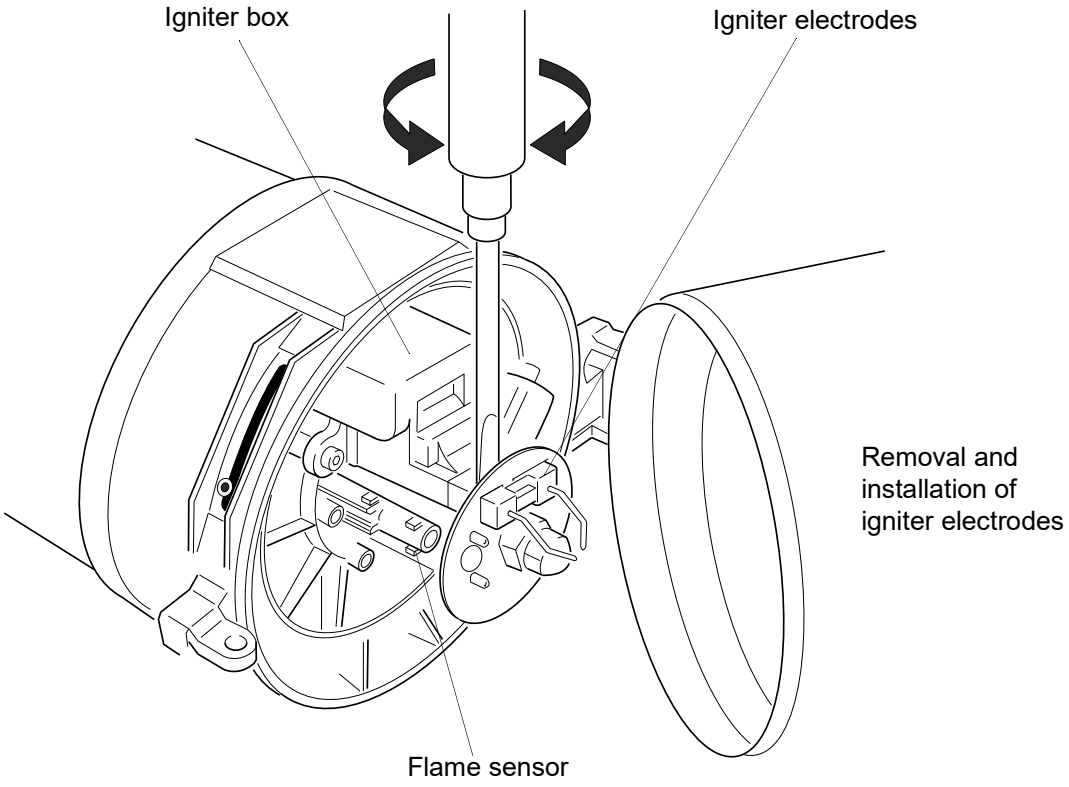
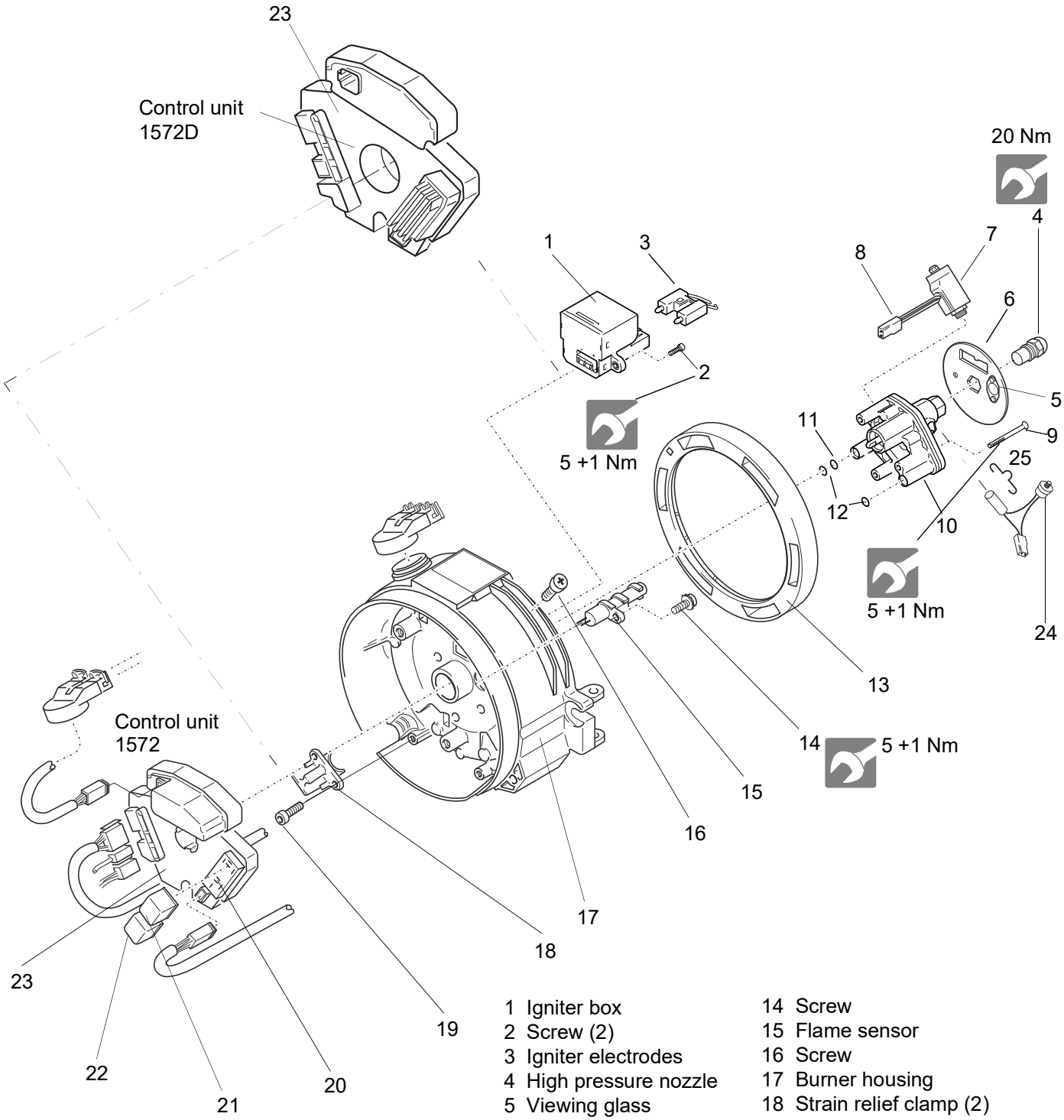


Fig. 4 Igniter Box and Flame Sensor, Replacement (Sheet 1 of 2)



1 Igniter box
2 Screw (2)
3 Igniter electrodes
4 High pressure nozzle
5 Viewing glass
6 Disk
7 Solenoid valve
8 Electrical connector
9 Screw (3)
10 Fuel pump
11 Filter screen
12 O-ring (2)
13 Rotating ring
14 Screw
15 Flame sensor
16 Screw
17 Burner housing
18 Strain relief clamp (2)
19 Screw (2)
20 Base plate
21 Relay
22 Relay
23 Control unit
24 Heating cartridge with thermostat
25 Clip)

Fig. 904 Igniter Box and Flame Sensor, Replacement (Sheet 2 of 2)

9.2.10 Heat Exchanger, Replacement

9.2.10.1 Removal

1. Remove temperature limiter (refer to 9.2.1.1).
2. Remove temperature sensor (refer to 9.2.2.1).
3. Remove burner (refer to 9.2.3.1).
4. Withdraw combustion chamber (1, Fig. 5) from heat exchanger (2).
5. Remove heat exchanger (2).
6. Perform procedures on components after disassembly (refer to 9.1.1).

9.2.10.2 Installation

1. Install combustion chamber (refer to 9.2.11.2).
2. Install burner (refer to 9.2.3.2).
3. Install temperature limiter (refer to 9.2.1.2).
4. Install temperature sensor (refer to 9.2.2.2).

9.2.11 Combustion Chamber, Replacement

9.2.11.1 Removal

1. Disconnect electrical connections to temperature limiter and temperature sensor.
2. Swing burner open (refer to).
3. Withdraw combustion chamber (1, Fig. 5) from heat exchanger (2) and remove.
4. Perform procedures on components after disassembly (refer to 9.1.1).

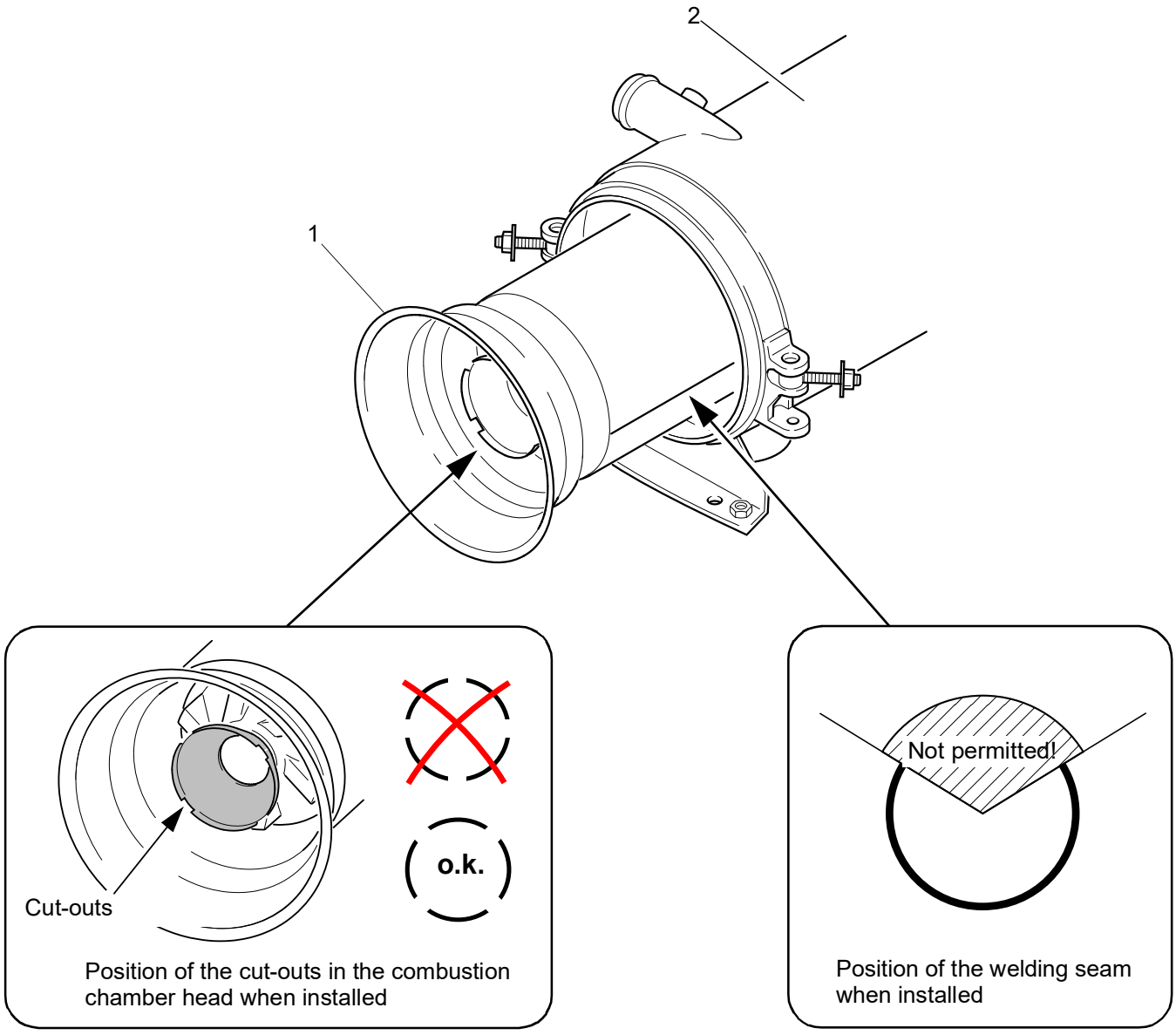


Fig. 5 Heat exchanger and combustion chamber replacement

9.2.11.2 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. 5) 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. 5). 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. 5.
  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. Swing burner closed (refer to).

NOTE:

Observe electrical wiring color coding when making connections.

3. Make electrical connections to temperature limiter and to temperature sensor.

10 Modifications and conversions

The constant development serves to optimize heaters. Devices that are already in operation can usually be converted or retrofitted. Appropriate modification kits are provided for this purpose. Information about this can be found on the Spheros homepage under the Service section.

10.1 Installation of the dust protection for the flame guard

The flame guard can be retrofitted with a dust protection. This increases the reliability of its function and reduces maintenance. The dust protection consists of 3 parts (see Fig. 1001/ Fig. 1002):
dust protection tube (1), spring (2) and disc (3).

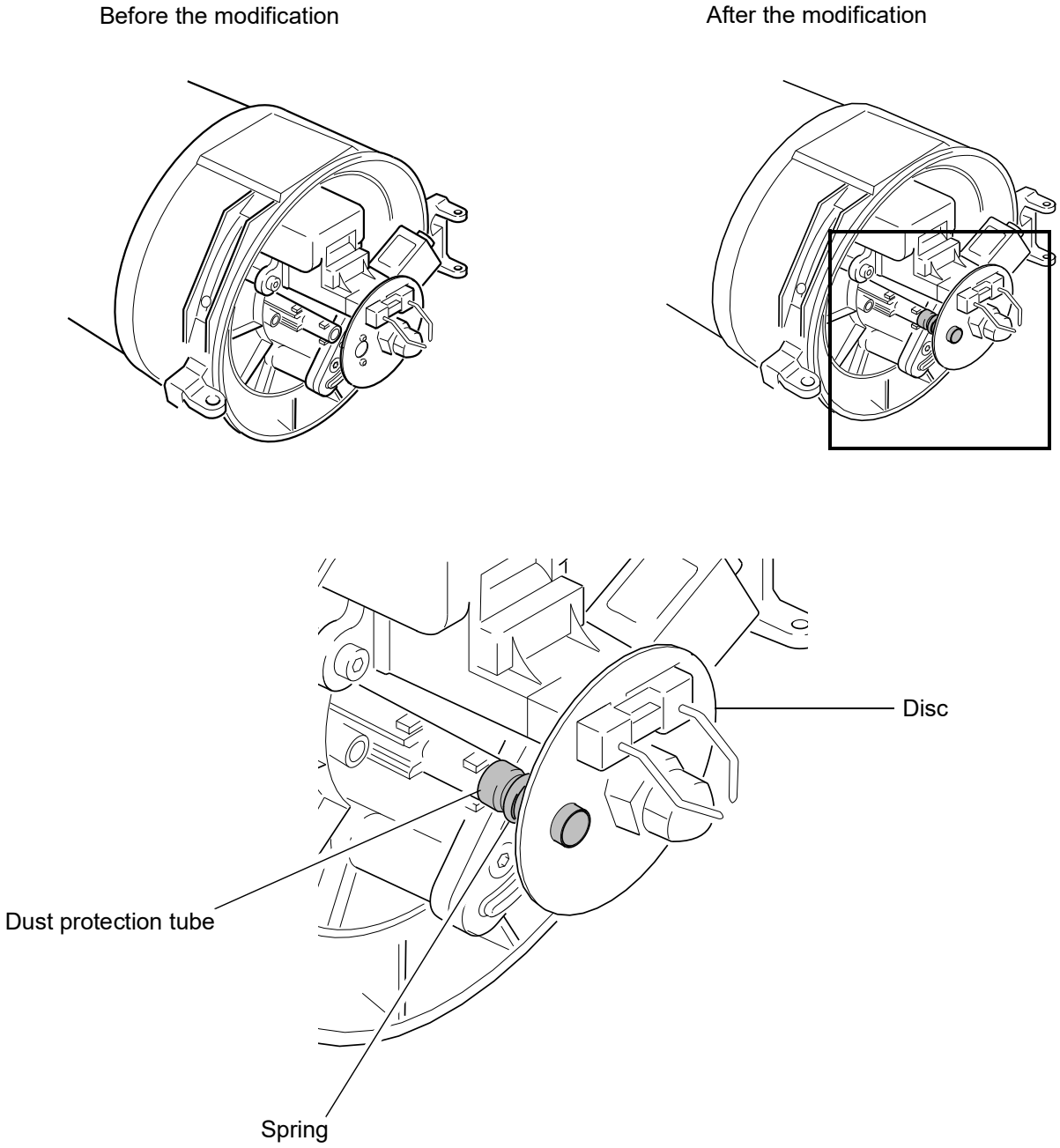


Fig. 1001 Flame guard dust protection

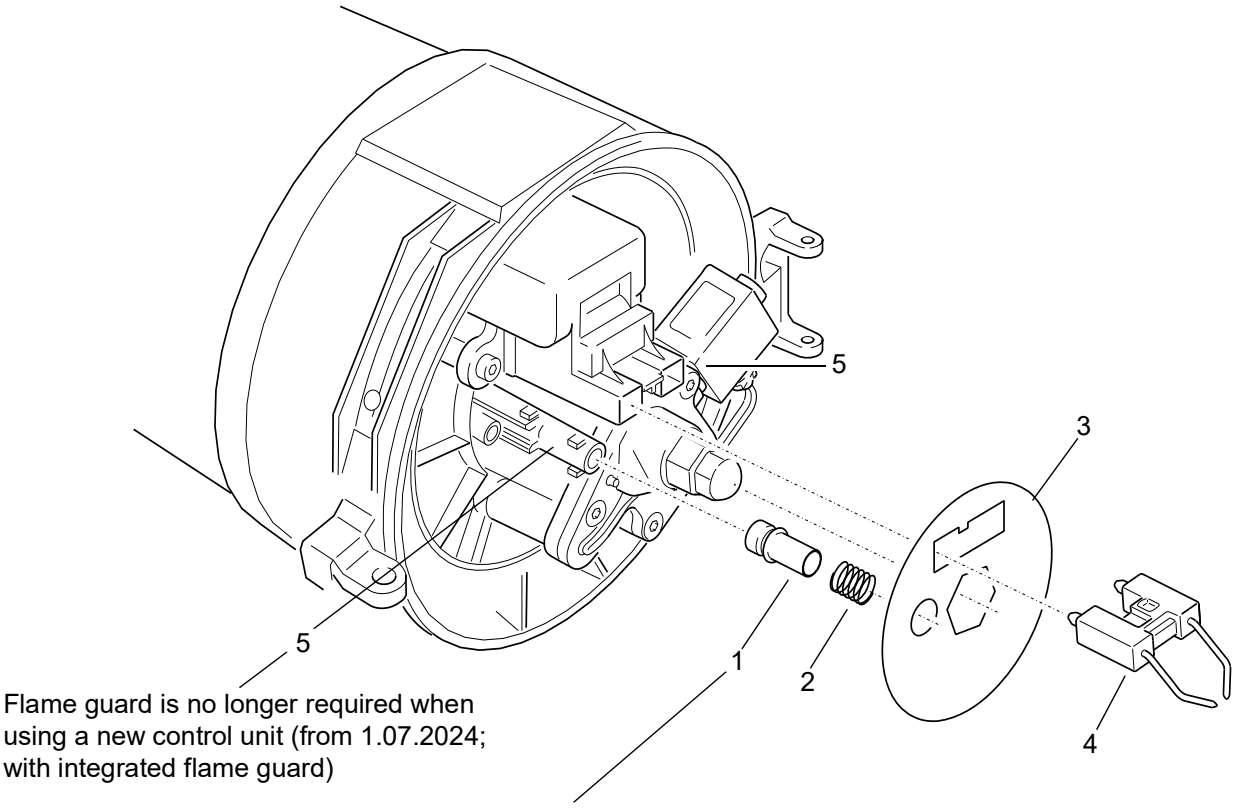


Fig. 1002 Flame guard dust protection - Installation

Dust protection kit

All required for the retrofit parts

– dust protection tube (1)
– spring (2) and
– disc (3)

are included in the dust protection kit Spheros Id. No.

– 11136322_
(for heaters equipped with nozzle block preheating)
– 11136323_
(for heaters without nozzle block preheating).
– 11149513_ SP kit Thermo II (new control unit from 1.07.2024) with nozzle block preheating
– 11149514_ SP kit Thermo II (new control unit from 1.07.2024) without nozzle block preheating

Installation

1. Remove burner head (see 9.2.3).
2. Remove ignition electrodes (4, Fig. 1002), refer to 9.2.8.
3. If installed, remove thermostat.
4. Remove disc (3) and discard it.
5. Pre-assemble new disc (3), tube (1) and spring (2).
6. Place new disc (3), tube (1) and spring (2) into position:
Place disc (3) via atomizer nozzle onto the nozzle block. The lower end of the tube (1) is thereby pushed onto the lens of the flame guard (5). Then turn the disc (3) so that the ignition electrode (4) can be replaced. Make sure that the components are correctly seated
7. If required, reinstall the thermostat. Pay attention to the correct positioning of the serrated washer.
8. Reinstall ignition electrodes (4), refer to 9.2.8.
9. Reinstall burner head (see 9.2.3).

11 Packaging, Storage and Shipping

11.1 General

The heater or its components shipped to Spheros for testing or repair must be cleaned and packaged so that they are protected against damage during handling, shipping and storage.

CAUTION

When shipping a complete heater assembly it must be drained completely. No coolant is allowed to escape when packaging or shipping.

Dummy plugs must be fitted to the coolant inlet and outlet as well as to the fuel lines.

In storage the ambient temperatures specified in Section 4 must not be exceeded.

Periodic heater maintenance

The heater
1) should be operated for 10 minutes at least once a month and
2) checked by a professional according to the maintenance plan at the start of the heating season at the latest.
Observe the following maintenance intervals. These apply to normal applications of Spheros heaters.
The vehicle manufacturer's regulations and the relevant regulations of the Federal Railway Authority (EBA) and its technical service also apply.
The relevant workshop manual must be used to carry out the work. If the devices are used in other vehicles or applications, the intervals may be shortened or extended.
Please contact your responsible Spheros partner in such cases.

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 DTT (Diagnose Thermo Test)	Date of commision

Fuel Diesel fuel ☐ Biodiesel ☐ Heating oil EL ☐ Paraffinic fuels ☐

Check / Maintenance	**Important notes**	**Check result** OK	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.	☐ ☐	☐ ☐	

Continued on next page

Check / Maintenance	Important notes	Check result OK	Check result not OK	Measured values, accomplished repairs
c) Fuel pump / fuel hoses **Note:** Observe technical information if biodiesel or FAME is used!	Replace the fuel pump every 5, the fuel hoses every 6 years, if biodiesel is used this interval is shortened	☐	☐	
d) Replace fuel screen with gasket in the pump.	**Technical Information Biodiesel / FAME see www.spheros.com**	☐	☐	
4. Burner head				
a) Inspect combustion air intake opening for clear passage.		☐	☐	
b) Inspect hood for damage.	Replace damaged parts.	☐	☐	
c) Depending on the version:		☐	☐	
- Clean the viewing window (disk) of the flame guard or		☐	☐	
- Check the dust protection tube of the flame guard and the lens of the phototransistor for contamination and clean if necessary, to do this, dismantle the dust protection tube.				
d) Inspect condition of the ignition electrodes, if required adjust or replace them.		☐	☐	
e) Replace atomiser nozzle.		☐	☐	
f) Check solenoid valve for leaks.	Activate combustion air motor using the diagnostic tool (DTT), 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.	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.-%) at 24V				
Thermo	10 ±0.5	☐	☐	
Thermo E 200	9.5 ±0.5	☐	☐	
Thermo E 300	10.0 ±0.5	☐	☐	
Thermo S	9.5 +1.5	☐	☐	
Thermo plus 230	9.0 +1.5	☐	☐	
Thermo plus 300/350	9.5 +1.5	☐	☐	
Thermo E+ 120	10.6 ±0.5	☐	☐	
Thermo E+ 200	9.5 ±0.5	☐	☐	
Thermo E+ 320	10 ±0.5	☐	☐	

Continued on next page

Check / Maintenance	Important notes	Check result OK	Check result not OK	Measured values, accomplished repairs
CO_2 (ppm) at 19V				
Rail versions	<1000	☐	☐	
Smoke spot number acc. to Bacharach (all devices)	≤ 4	☐	☐	
Fuel pump pressure according to Workshop Manual				
Thermo, Thermo S	10 bar	☐	☐	
Thermo E 200, Thermo plus	8 +1 bar	☐	☐	
Thermo E 320	9 +1 bar	☐	☐	
Thermo E+	9 +0.5 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 (DTT).		☐	☐	
c) 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

Spheros Germany GmbH
Friedrichshafener Str. 7 | 82205 Gilching | Germany | www.spheros.com