

Workshop Manual

Water Heaters

Thermo 230

Thermo 300

Thermo 350

with control unit 1572D

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1 Introduction

1.1 Scope and Purpose

This repair shop manual is intended to support familiarized personnel in the repair of water heaters Thermo 230, 300 and 350.

The water heater may only be operated with the fuel specified on the model plate and the relevant designated type of electrical connection.


1.2 Applicability of Manual


This manual is applicable only for heaters identified on the title page.

In combination with control unit 1572D additionally a different type of electronic ignition coil is installed (refer to 2.7).

1.3 Meaning of Warnings, Cautions and Notes

WARNINGS, CAUTIONS, and NOTES in this manual have the following meaning:

 WARNING
This heading is used to highlight that non-compliance with instructions or procedures may cause injuries or lethal accidents to personnel.

 CAUTION
This heading is used to highlight that non-compliance with instructions or procedures may cause damage to equipment.

NOTE
This heading is used to highlight and draw specific attention to information.

1.4 Additional Documentation to be used

This workshop manual contains all information and procedures necessary for the repair of heaters Thermo 230, 300 and 350.

The use of additional documentation is normally not necessary.

Operating instructions and installation instructions may be used as complementary information as necessary.

1.5 Safety Information and Regulations

The general safety regulations for the prevention of accidents and the relevant operating safety instructions have to be observed at all times.

"General Safety Regulations" beyond the scope of these regulations are detailed in the following.

The specific safety regulations applicable to this manual are highlighted in the individual chapters by Warnings, Cautions, and Notes.

1.5.1 General Safety Notes

The year of first operation must be permanently marked on the identification label by removing the relevant number of the year.


The heaters are cleared for heating the vehicle engine and the passenger cabin. The use of the heater in vehicles not subject to the EU Directive 70/156/EEC (e.g. ships) is partly governed by regional regulations. For heaters designed for installation in rail vehicles, type approval has been granted (not for vertical models) by the Federal Railway Authority with the type approval number: EBAAZ3/0141/04.


The heater may only be fitted in vehicles or in independent heating systems with a minimum coolant capacity of 2.64 Gal (10 liters).

The heater may only be installed in motor vehicles or in independent heating systems with a minimum coolant capacity of 1.58 Gal (6 liters).

The heater must not be installed in the passenger or driver compartments of vehicles. Should the heater nevertheless be installed in such a compartment, the installation box must be sealed tight against the vehicle interior.

There must be sufficient ventilation of the installation box from the exterior in order not to exceed a maximum temperature of 185 °F (85° C) in the installation box. Excessive temperatures may cause malfunctions.

 WARNING
Due to the danger of poisoning and suffocation the heater must not be operated, not even with timed operation, in enclosed areas such as garages or workshops not equipped with an exhaust venting facility.
At filling stations and fuel depots the heater must be switched off to prevent explosions.

 CAUTION
Where flammable fumes or dust may build up (e.g. in the vicinity of fuel, coal, wood, cereal depots, or similar installations) the heater must be switched off to prevent explosions. The heater must not be operated near flammable materials such as dry grass and leaves, cardboard boxes, paper, etc.

In the vicinity of the water heater a temperature of 110° C (230 °F) storage temperature must not be exceeded under any circumstances (e.g. during body paint work). A violation of this temperature limit may cause permanent damage to the electronics.

When checking the cooling water level proceed in accordance with the vehicle manufacturer’s instructions. The water in the heating circuit of the heater must contain a minimum of 20% of a quality brand anti-freeze.

Additives in the heating circuit must not affect metals, plastics and rubber and must leave no deposits.

The opening pressure in the vehicle cooling system - normally indicated on the radiator filler cap - must be between 0.4 and 2.0 bar above operating pressure (also applicable to separate heating circuits).

1.6 Legal Provisions for Installation

With effect from 4/03, Type Approvals pursuant to EC Directives 72/245/EEC (EMC) and 2001/56EC (Heating Systems) were granted for the heaters Thermo 230 / Thermo 300 / Thermo 350 with the following EC Type Approval Numbers:

e1*72/245*95/54*1010*--

e1*2001/56*0007*-- for Thermo 230

e1*2001/56*0008*-- for Thermo 300

e1*2001/56*0009*-- for Thermo 350


Up to 4/03, General Design Certifications existed for these heaters.

Installation is governed above all by the provisions in Annex VII of Directive 2001/56/EC.

NOTE
The provisions of these Directives are binding within the territory governed by EU Directive 70/156/EEC and should similarly be observed in countries without specific regulations. (Extract from Directive 2001/56/EC Annex VII)

1.7.1. A clearly visible indicator within the user's field of vision must show when the heater is switched on or off.

NOTE
For further notes and provisions relating to the installation of the heater in vehicles, refer to the installation instructions.

 WARNING
Failure to follow the installation instructions and the notes contained therein will lead to all liability being refused by Spheros. The same applies if repairs are carried out incorrectly or with the use of parts other than genuine service parts. This will result in the invalidation of the type approval for the heater and therefore of its homologation / EC type licence.

Installation Instructions for Spheros fuel tanks for the fuel supply of water heaters in vehicles:

- in buses and trains the installation is not permitted in.
- the passengers’ or driver’s compartment.
- the fuel filler neck must not be located in the passengers’ or driver’s compartment of any vehicle.
- fuel containers must either be equipped with a vent cap or any other type of ventilation (vent line).

Only vent caps in accordance with DIN 73400 may be used.

All fuel containers offered in the Spheros Accessories Catalogue are suitable for a maximum operating pressure of 2.18 psi (0.15 bar) overpressure.

All fuel containers offered in the Spheros Accessories Catalogue are subjected during manufacture to individual pressure testing with at least 4.35 psi (0.3 bar) overpressure.

- The operational state of the heater, i.e. at least an indication "on" or "off" must be easily and clearly visible.

For heaters in vehicles not ruled by the EU Directive but other regulations, the acceptance by the relevant authority is required as applicable.

1.7 Corrections and Improvements

Deficiencies, improvements, or proposals for correction of this workshop manual are to be mailed to:

Spheros North America, Inc.
5536 Research Drive
Canton MI. 48188

Telephone: 1-734-218-7350
Fax: 1-734-487-1569
website: www.spheros.us / info@spheros.us

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
- defrost the windscreen
- 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.

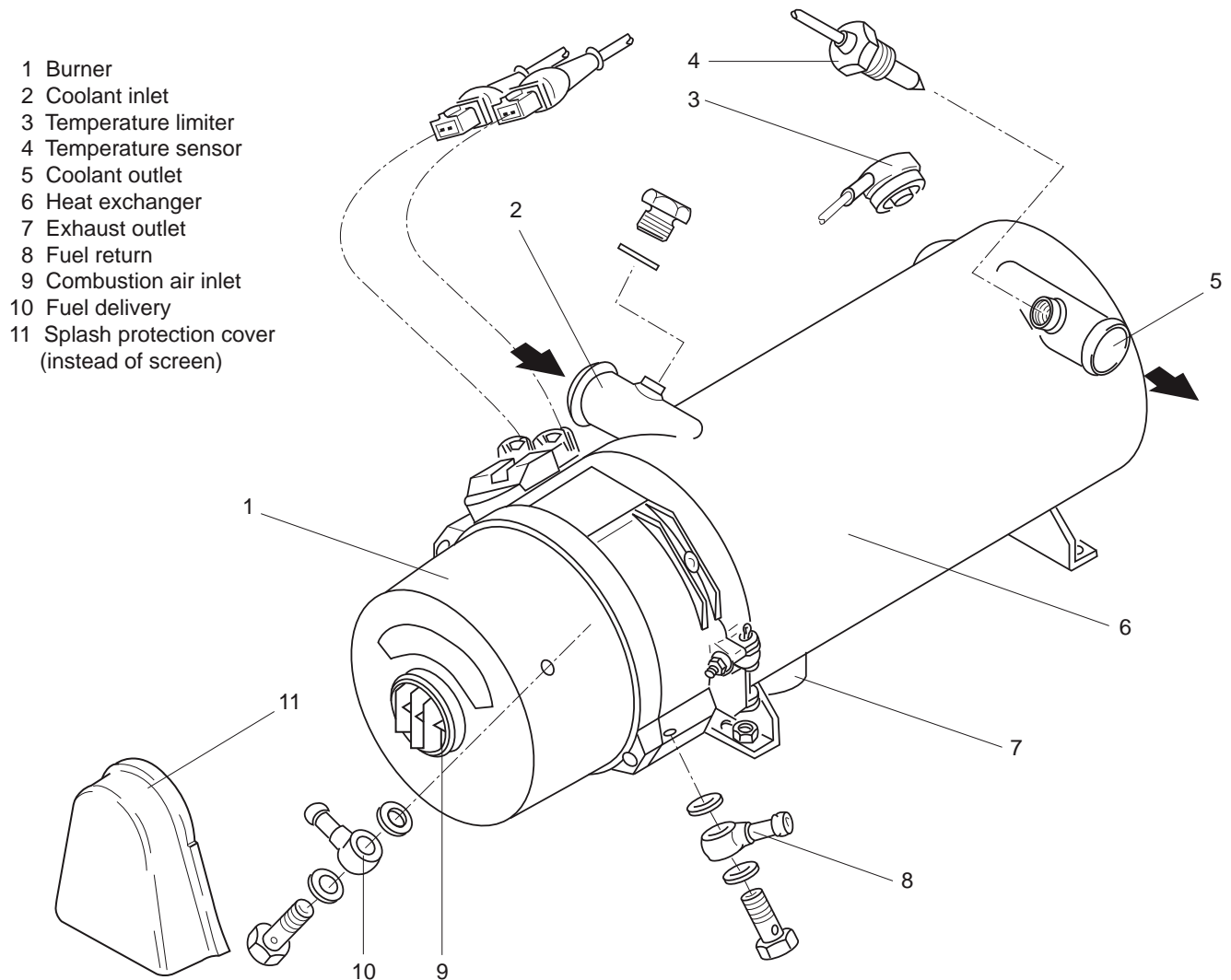
The heaters Thermo 230, 300 and 350 basically consist of

- the combustion air fan
- the fuel pump with nozzle block and nozzle
- the heat exchanger
- the combustion chamber
- the electronic ignition coil with igniter electrodes

For control and monitoring the heater includes

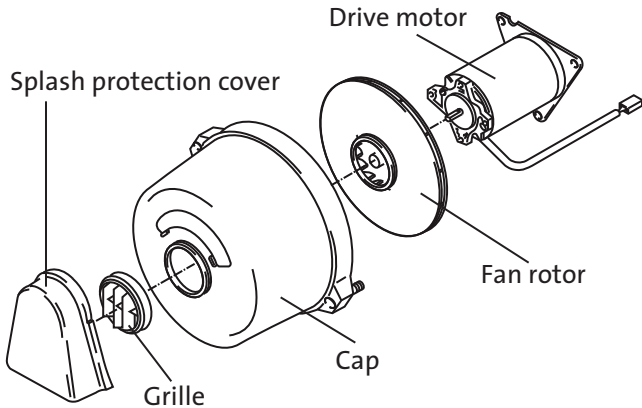
- a control unit
- a flame sensor
- a temperature sensor
- a temperature limiter (automatic reset)

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



2.1 Combustion Air Fan

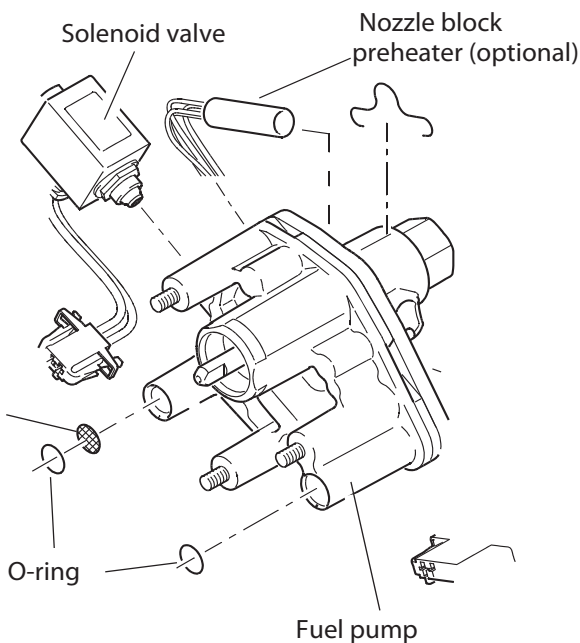
The combustion air fan supplies the air required for combustion from the combustion air inlet to the combustion chamber.



The fan consists of a drive motor with fan rotor. Air is taken in through a splash protection cover or a screen and the cap.

2.2 Fuel Pump

The fuel pump delivers the fuel and is driven by the drive motor via a clutch. The fuel is pressurized in the pump to approximately 10 bar (145 psi) and diffused by a high pressure nozzle. A screwed on solenoid valve controls the fuel flow to the nozzle.



2.2.1 Nozzle block pre-heater

NOTE

For operation with PME (Biodiesel) the installation of a nozzle block pre-heater is mandatory. At extremely low temperatures malfunctions may occur without a nozzle block pre-heater.

At a temperature of $< 32\text{ }^{\circ}\text{F}$ ($0\text{ }^{\circ}\text{C}$) 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 $46\text{ }^{\circ}\text{F}$ ($+8\text{ }^{\circ}\text{C}$).

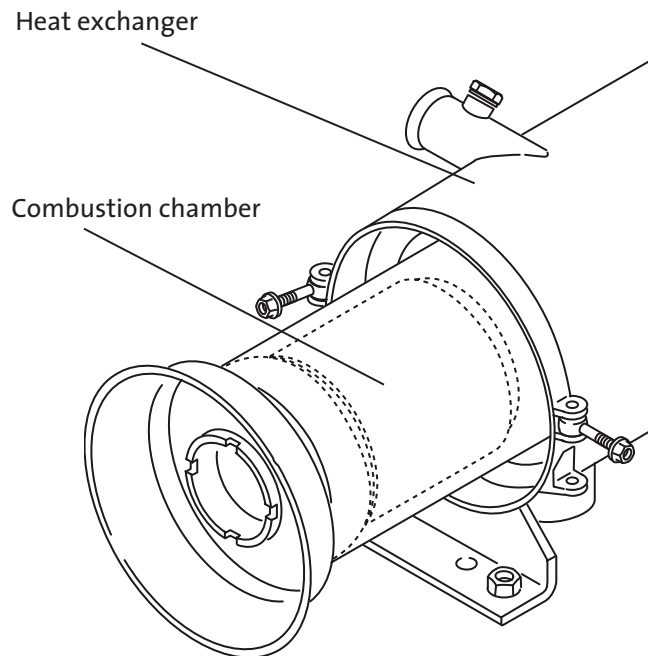
If the heater is not equipped with a nozzle block pre-heater a retrofit is possible.

2.3 Heat Exchanger

The heat exchanger transfers the heat generated by combustion to the coolant circuit.

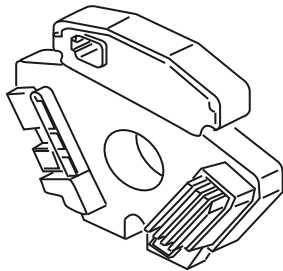
2.4 Combustion Chamber

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

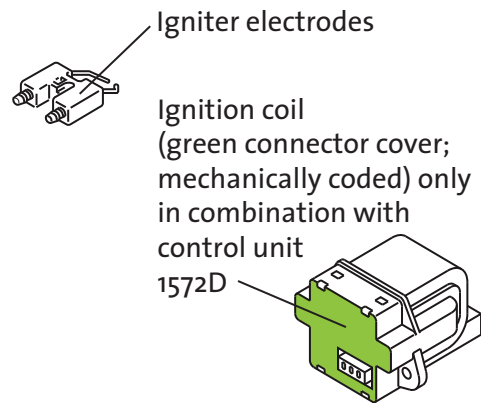


2.5 Control Unit

The control unit 1572D is the central component to ensure controlled operation and monitoring of combustion.



Control unit 1572D

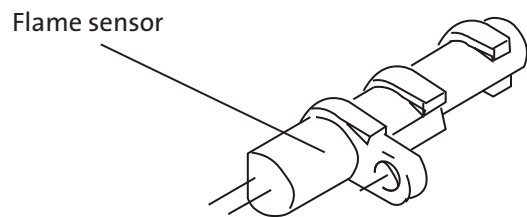


Igniter electrodes

Ignition coil (green connector cover; mechanically coded) only in combination with 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.



Flame sensor

2.7 Electronic Ignition Coil with Igniter Electrodes

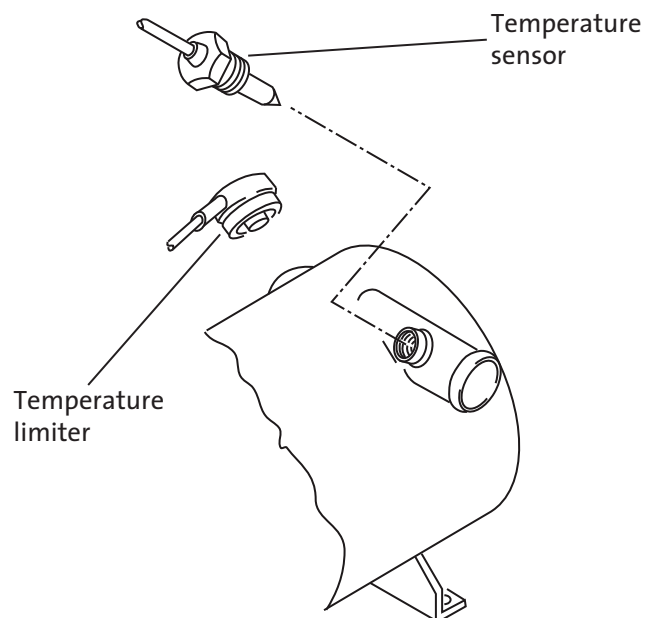
The electronic ignition coil generates the high voltage for igniting the fuel/air mix by a high voltage ignition spark across the electrodes.

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 257 °F (125 °C) to switch off the heater. The temperature limiter can be reset manually or has an automatic reset.

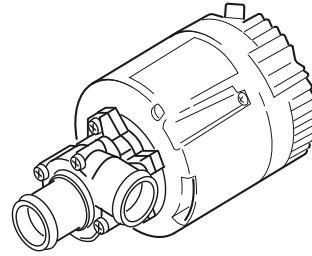
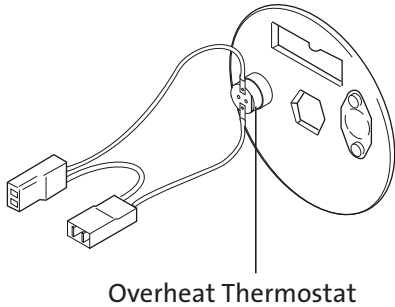


Temperature sensor

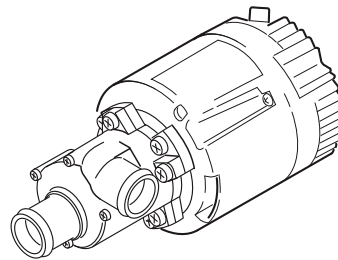
Temperature limiter

2.10 Overheat Thermostat for burner (Thermo heaters operated in vertical position only)

The overheat thermostat is screwed onto the disk and electrically connected to the solenoid valve of the fuel pump. When the burner overheats the thermostat causes an error lockout.



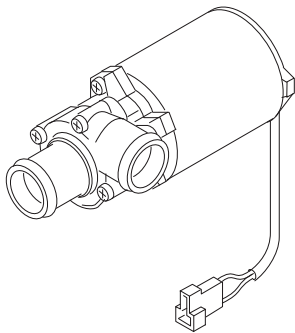
Aquavent 6000C
(U 4855)



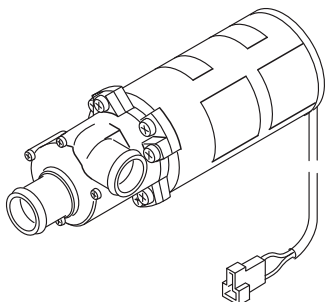
Aquavent 6000 SC
(U 4856)

2.11 Circulating Pump

The externally mounted circulating pump ensures proper coolant circulation in the vehicle and heater circuit. The pump is activated by the control unit to operate as long as the heater is in operation. The heaters may be operated with circulating pump Aquavent 5000 (U4814), Aquavent 5000S (U4854), Aquavent 6000C (U4855), Aquavent 6000SC (U4856).



Aquavent 5000
(U 4814)



Aquavent 5000S
(U 4854)

2.11.1 Circulating Pump

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

Soft start

Motor run-up is slow with no stress for the material. It takes 5 seconds to reach maximum speed.

Dry run protection (only U4855 and U4856)

Protection against dry running is integrated into the circulation 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

When operating speed drops below 571 rpm the motor is switched off after approx. 1 second by means of the failure mode.

If no complete revolution is achieved within 1 second with the motor powered, the motor is switched off by means of the failure mode.

Overload protection

After completion of the soft start an overload protection is activated to limit the power consumption and keep the speed at 5550 rpm. That means that the motor is not damaged in case of circulating pump hydraulic overpressure.

Failure mode

The failure mode stops the motor in case of malfunctions.

After approx. 5 seconds the failure mode switches the motor to the power saving sleep mode.

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.

Motor reactivation

The motor can be reactivated out of the sleep mode by disconnection of the power supply for approx. 2 minutes. After power re-connection the motor will again run up with a soft start.

Reverse pole protection

The motor is not equipped with an internal reverse pole protection. In combination with a wiring harness and a 25 A fuse the motor is protected against reverse poling.

2.12 Heated Fuel Filter (for PME Biodiesel use)

A fuel filter can be fitted that may be heated if desired. When the integrated filter heater is connected, the temperature switch will turn the filter heater on at a fuel temperature of $\approx 0.5 \pm 2.5$ °C (33 ± 4.5 °F) and turn it off at $\approx 5.5 \pm 2.5$ °C (42 ± 4.5 °F).

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 a minimum, an operating indicator light must be provided.

Switch off begins 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 pre-heater for extreme low temperatures (required for operation with PME or biodiesel).

Heaters with control unit 1572D

When connecting terminal +61 the heaters may operate in the auxiliary heating mode of operation.

Operating Thresholds

Control Unit	Ident. No. 63482F (Bus)
Auxiliary heating	
Upper operating point	185 °F (85 °C)
Lower operating point	172 °F (78 °C)
Parking heating, normal	
Upper operating point	185 °F (78 °C)
Lower operating point	158 °F (70 °C)
Parking heating, economy	
Upper operating point	158 °F (70 °C)
Lower operating point	131 °F (55 °C)
Gradient evaluation	YES
Hysteresis adaptation	YES

3.1 Switch On

Upon switch on the operating indicator light goes on. Combustion air fan, fuel pump and circulating pump start operation. (If fitted and temperature is < 0 °C (32 °F) nozzle block pre-heater 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 electronic ignition coil 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 starts the control idle period. Heater operation is resumed when the temperature drops below the lower operating point.

Heaters with control unit 1572D Gradient evaluation

With a low coolant flow rate or poor venting, the temperature in the heating mode rises too quickly. If gradient evaluation is available, the control unit is able to detect any undue temperature rise and can automatically shift the upper operating point to a lower value. Any tripping of the temperature limiter due to residual heat after the combustion operation has been terminated can thus be prevented.

Control idle period

A rise in temperature above the upper operating 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 circulating pump however continue their operation. After approximately 120 seconds (for heaters with control unit 1572D) run-down is completed with deactivation of the combustion air fan.

The circulating pump remains in operation during the control idle period. The operating indicator light remains 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 circulating pump are deactivated after approximately 120 seconds for heater 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)

If terminal +61 (ALT.Charge Indicator) is connected and active, the heater will be operating in the auxiliary heating mode. The lower temperature threshold for restarting the burner after the control idle period is completed is raised above that for parking mode 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 172 °F (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 158 °F (70 °C).

3.6 Heater Lockout (heaters with control unit 1572D)

After the heater has performed eight consecutive start attempts due to a malfunction or after five consecutive 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.

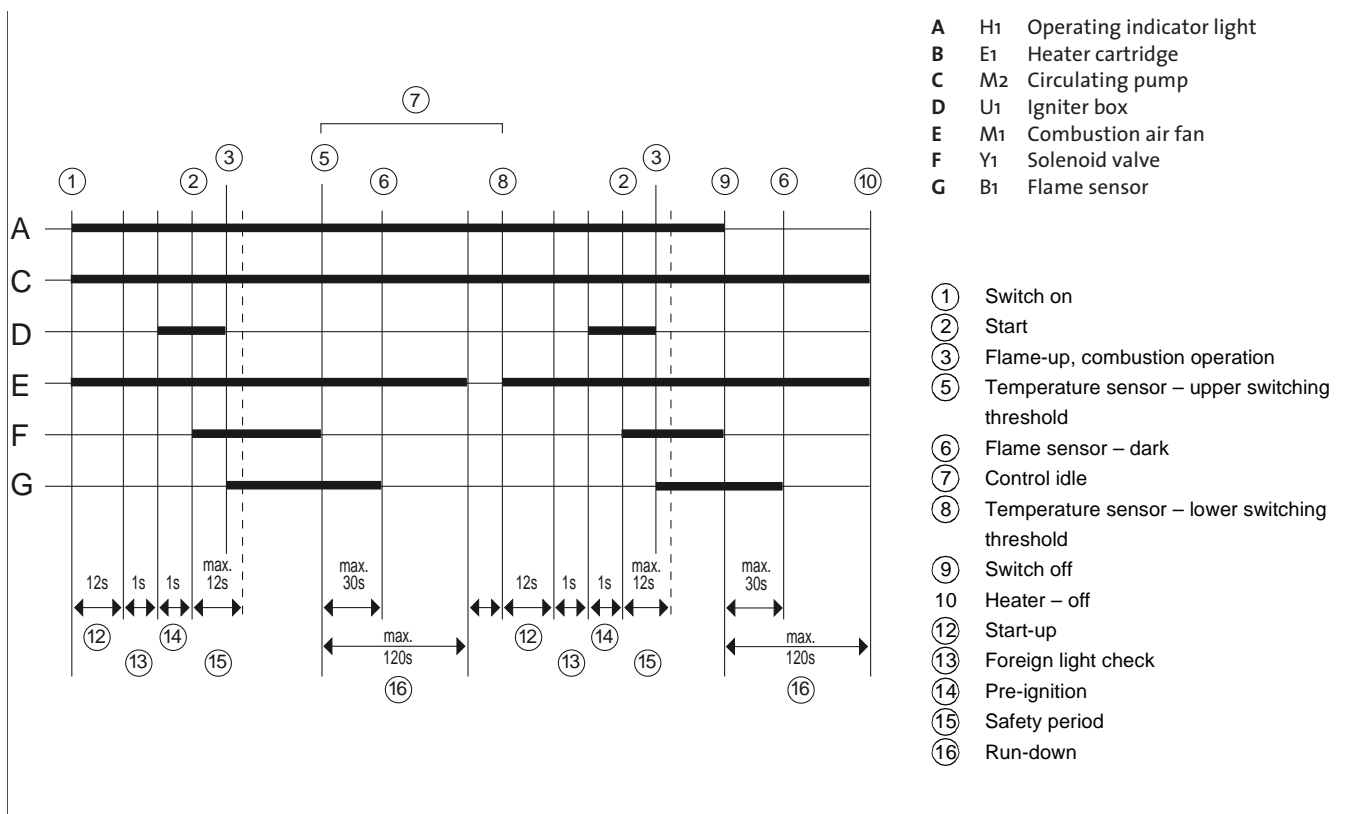


Figure 1: Functional Sequence (heaters with control unit 1572D)

3.7 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 circulating 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
- electronic ignition coil

Malfunctions during start-up:

- short or open circuit of electronic ignition coil
- 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 circulating pump. When using the circulating pump Aquavent 5000 approximately 15 seconds after switch-on the circulating 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 run-down:

Detection of a flame after more than 30 seconds after start of run-down with the circulating 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. Dependent on heater configuration:

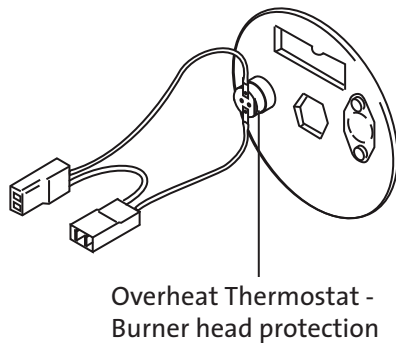
the reset button on the temperature limiter must be reset manually except where the limiter is of the auto-reset type.

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

Malfunction by overheating of the burner in vertical installations (MCI):

Overheating of the burner head causes the burner protection, overheat thermostat to initiate an error lockout at 302 °F (150 °C).

The fuel solenoid valve closes, the fuel supply is cut off and a run-down is initiated. An auto-reset occurs after cool-down of the thermostat.



3.8 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
- 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 drive motor defective
- F 09 circulating pump defective
- F 10 temperature limiter defective / overheating
- F 11 electronic ignition coil defective
- F 12 error lockout due to repeated malfunction or repeated flame failure
(8x no start-up or 5x flame failure)

* A response of the burner protection, overheat thermostat will be stored in the control unit as a flame-out (F 02) in the case of vertically installed heaters (MCI).

4 Technical Data

Where no threshold values are specified technical data are understood to include standard tolerances for heater units of $\pm 10\%$ at ambient temperature of $+ 68^{\circ}\text{F}$ ($+ 20^{\circ}\text{C}$) and at nominal voltage.

4.1 Electrical components

Control unit, fan and circulating pump motors, solenoid valve, electronic ignition coil, heater cartridge, nozzle block pre-heater and timer are 24V components.

Temperature limiter, flame sensor, temperature sensor and switches are voltage independent components.

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

4.2 Fuel

The suitable propellant is the Diesel fuel specified by the vehicle manufacturer.

Only the type of fuel indicated on the identification plate may be used. Also Diesel fuel with an addition of 5 to 20% PME (vegetable oil methyl ester), class EL fuel oils (not fuel oil L) may be used if their quality is in accordance with the German standard.

A bad influence caused by additives is not known.

When using fuel from the vehicle tank the information about additives of the vehicle manufacturer must be observed.

When using fuel from a separate fuel tank and at temperatures below 32°F (0°C), winter Diesel fuel must be used or a winter petroleum additive or flow improvers added to the Diesel fuel observing the relevant mixing ratios recommended by the manufacturer of the additive.

Heater data

Heater		Thermo 230	Thermo 300	Thermo 350
Mark of conformity up to 04/03		~ S230	~ S229	~ S228
EC type approval number e1*2001/56*		0007*--	0008*--	0009*--
Heater principle		High pressure atomizer		
Heating flow	Btu/h	80,000	104,000	120,000
	Kw	23	30	35
Fuel		Diesel / Diesel PME Mix (Biodiesel B5 - B20 max.)		
Fuel consumption	US Gal/hr	0.79	1.05	1.14
	l/hr	3.0	4.0	4.35
	Kg/h	2.5	3.3	3.7
Nominal voltage	Volts	24		
Operating voltage	Volts	20 ... 28		
Nominal power consumption (without circulating pump)	Watts	65	110	140
Permissible operating ambient temperature range (heater, control unit, circulating pump)	°F (°C)	-40 ... +185 (-40 ... +85)		
Permissible storage temperature	°F (°C)	+230max. (+110 max)		
Permissible operating overpressure	bar	0.4 ... 2.0		
	PSI	5.8 ... 29		
Heat exchanger coolant capacity	Litre	1.8		
	US Quart	1.9		
Minimum capacity of coolant circuit	Litre	10		
	US Quart	10.56		
CO ₂ in exhaust at nominal voltage	Vol.-%	10 ±0.5 to 500 m (1640 ft.) above sea level		
Dimensions of heater	mm (in.)	Length 610 (24.015)		
	mm (in.)	Width 246 (9.685)		
	mm (in.)	Height 220 (8.661)		
Weight of heater	kg (lb.)	19 (41.9)		

Circulating pump data

Circulating pump		Aquavent 5000	Aquavent 5000 S	Aquavent 6000C	Aquavent 6000 SC
Volume of flow	l/h	5200	5200	6000	6000
	US Gal/m	23	23	26.4	26.4
Nominal voltage	Volts	12 ... 24			
Operating voltage	Volts	10 ...14/20 ... 28			
Nominal power consumption	Watts	104	104	210	210
Dimensions	mm (in.)	Length 229 (9)	Length 249 (9.8)	Length 224 (8.8)	Length 229 (9)
	mm (in.)	Width 100 (3.9)	Width 100 (3.9)	Width 115 (4.5)	Width 115 (4.5)
	mm (in.)	Height 105 (4.1)	Height 105 (4.1)	Height 110 (4.3)	Height 110 (4.3)
Weight		4.6 (2.1)	4.8 (2.2)	5.3 (2.4)	5.5 (2.5)

Optional fuel filter heater		
Nominal voltage	Volts	24
Nominal power consumption	Watts	240
Switch-on point	°C (°F)	0.5 ±2.5 (33 ±4.5)
Switch-off point	°C (°F)	5.5 ±2.5 (42 ±4.5)

5 Troubleshooting

5.1 General

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

! CAUTION

Troubleshooting requires profound knowledge about components 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.

! CAUTION

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

5.2 General Fault Symptoms

The following tables (Fig. 3 and Fig. 4) lists possible fault symptoms of a general nature.

Symptom	Probable Cause
Fault in electrical system	
Operating indicator light is not on, no heater operation.	<ul style="list-style-type: none"> • no power supply • fuses • wiring to terminals of connector A of control unit.
Fuse F2 blows	Short circuit in circulating pump or in wiring to heater.
Fuse F3 blows	Short circuit in wiring to heater/motor/nozzle block pre-heater (if installed)
Normal heater operation, operating indicator light is out.	Operating indicator light defective or wiring to light open or shorted.
Fault in water system	
Circulation pump not operating	<ul style="list-style-type: none"> • Failure mode activated <p>The failure mode switches the motor off in case of malfunctions. After approximately 5 sec. the failure mode switches the motor to the power saving sleep mode.</p> <p>In the sleep mode the internal power consumers of the motor electronics are switched off. The power consumption in this mode then amounts to < 2 mA.</p> <p>The motor can be reactivated out of the sleep mode by disconnection of the power supply for approx. 2 minutes. After power re-connection the motor will again run up with a soft start.</p>

Figure 3: General Fault Symptoms (Sheet 1 of 2)

Symptom	Probable Cause
<p>Heater operation stops because heat exchangers connected do not dissipate enough heat.</p>	<p><u>Rate of flow too low, because</u></p> <ul style="list-style-type: none"> • air in heater, in heat exchangers or system sections. • valves (flow regulators) throttled, contaminated or closed. • contamination in system, e.g. in areas of restricted flow. • circulating pump rate of delivery insufficient (air in pump housing). wrong sense of rotation – check wiring colors (black + / brown –). • not enough anti-freeze - slushing. • excessive system resistance (especially high when cold). • circulation pump defective. <p><u>Heat exchanger does not dissipate enough heat, because</u></p> <ul style="list-style-type: none"> • air in heat exchangers or in system sections. • contaminated heat exchanger surfaces (external). • insufficient air intake or exit. • fan: rate of delivery low / wrong sense of rotation / resistance too high. • incorrect anti-freeze concentration - too high. • heat exchanger of too low capacity.
<p>Rough calculation of rate of flow</p> <p>Rate of flow in [l/h] =</p>	$\frac{\text{heat flow [kW] according to ident. label}}{\text{temperature difference } \Delta t \text{ in [K] or [}^\circ\text{C] measured between heater water inlet and outlet (e.g. with contact thermometer)}} \times 860$
<p>Fault in fuel supply</p> <p>No fuel delivery to heater</p>	<ul style="list-style-type: none"> • fuel tank empty. • kinked, closed, contaminated or leaking lines. • paraffin deposits or water captured in fuel filter or fuel lines. • vent in tank clogged. • fuel lines interchanged. • fuel filter contaminated. • fuel screen in pump contaminated.
<p>Wrong combustion</p> <p>CO₂ value cannot be set to rated value, combustion irregular.</p>	<ul style="list-style-type: none"> • air bubbles in suction line (suction line leaking). • fuel filter contaminated or leaking. • fuel system integration leak (suction height, low pressure in tank); observe installation instructions. • fuel pump defective (pump pressure). • return line throttled. • filter screen in pump contaminated. • O-ring sealing on fuel pump no longer effective (ageing) • nozzle jet defective. • combustion air or exhaust lines throttled or closed. • drive motor speed too low.

Figure 4: General Fault Symptoms (Sheet 2 of 2)

5.3 Fault Symptoms during Functional Checkouts

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 section 3.9).

Diagnostic Computer

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

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".

Spheros Thermo Test PC based Heater Diagnosis

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

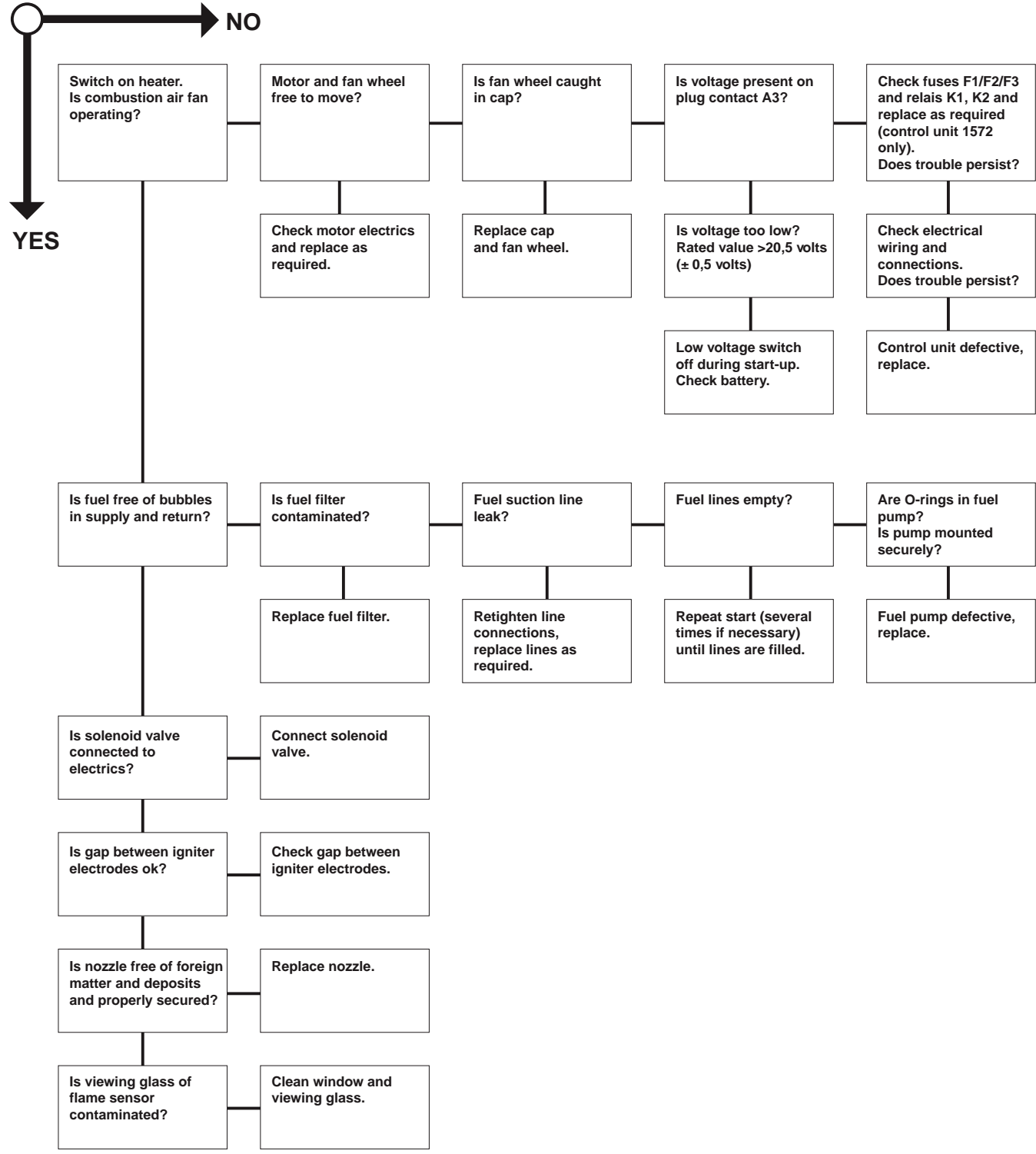
For details refer to operating instructions for "Spheros Thermo Test PC based Heater Diagnosis".

5.3.2 Fault Symptoms

5.3.2.1 Fault Symptom "No Start"

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.

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

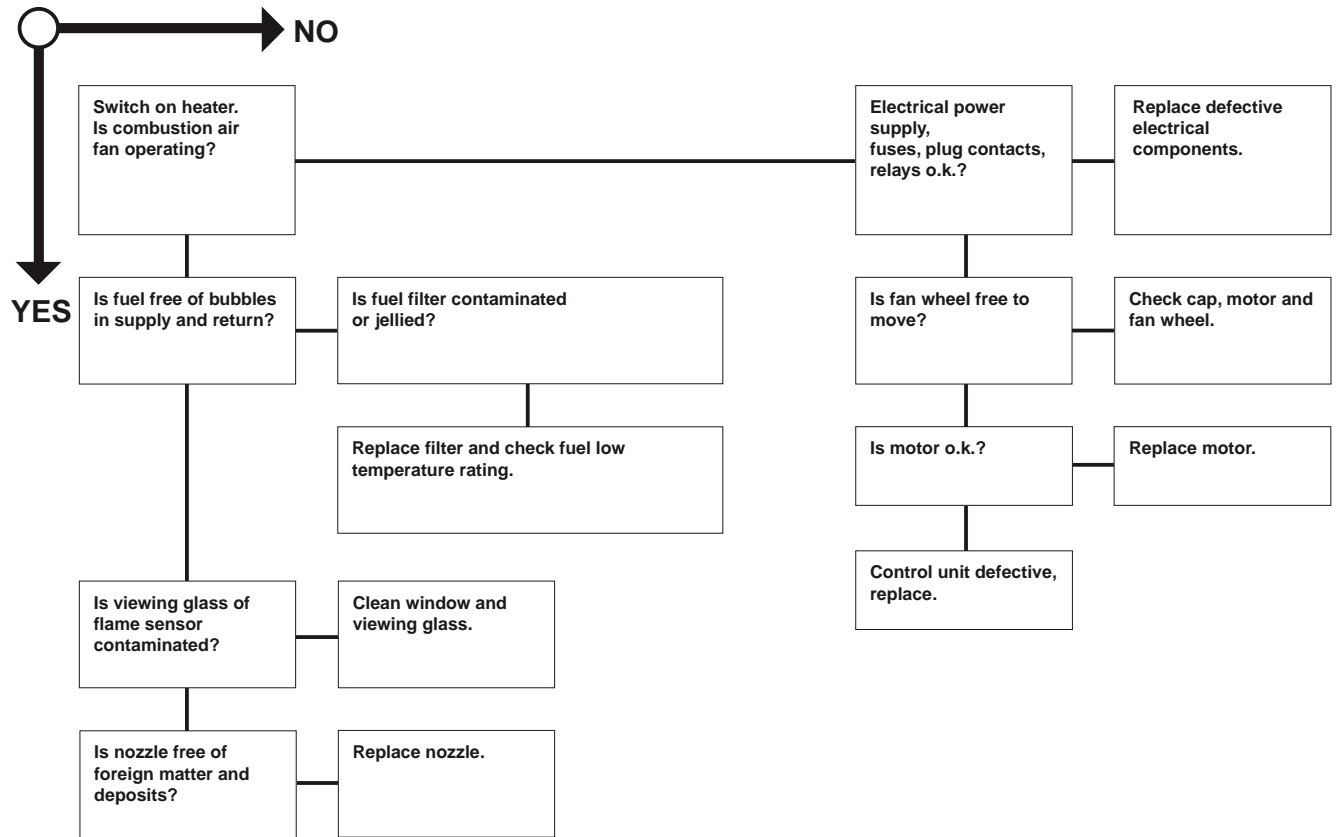


5.3.2.2 Fault Symptom "Flame-out"

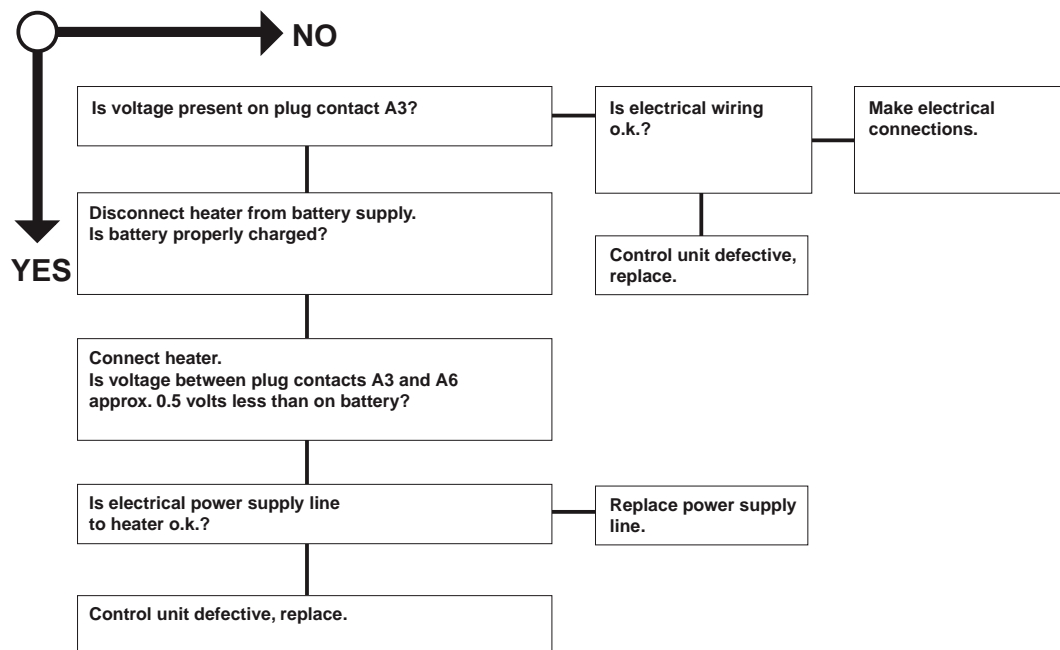
NOTE

Heaters with control unit 1572D:
 If the heater performs 5 subsequent attempts to start due to a malfunction, the heater enters an error lockout

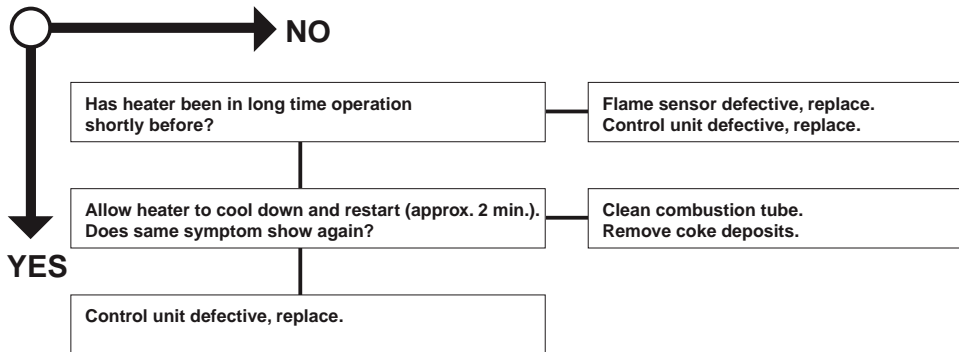
and stops any further attempts to start. This error lockout is superior to the normal error lockout condition. The error lockout reset is achieved by switching the heater on and disconnection of the heater power supply during run-down.



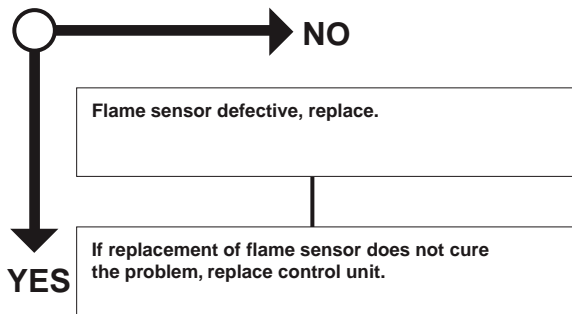
5.3.2.3 Fault Symptom "Low Voltage"



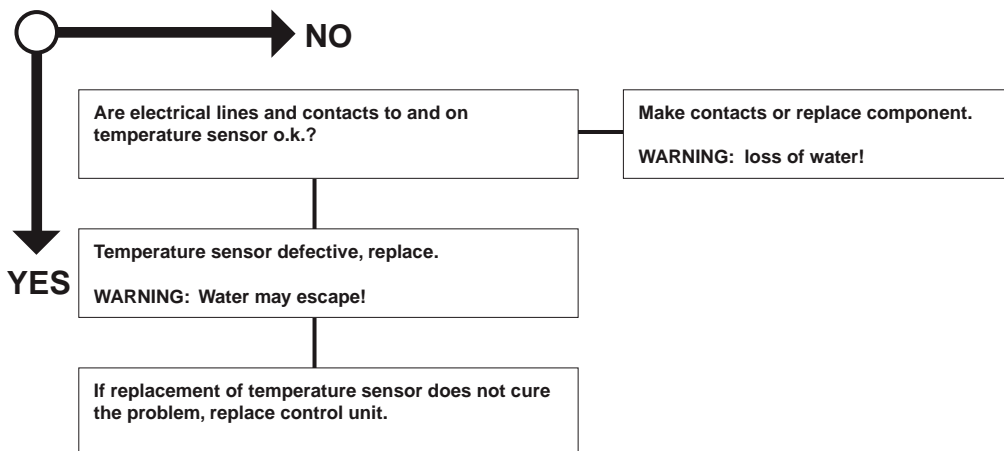
5.3.2.4 Fault Symptom "Unexpected Light Detection during Run-up or Run-down"



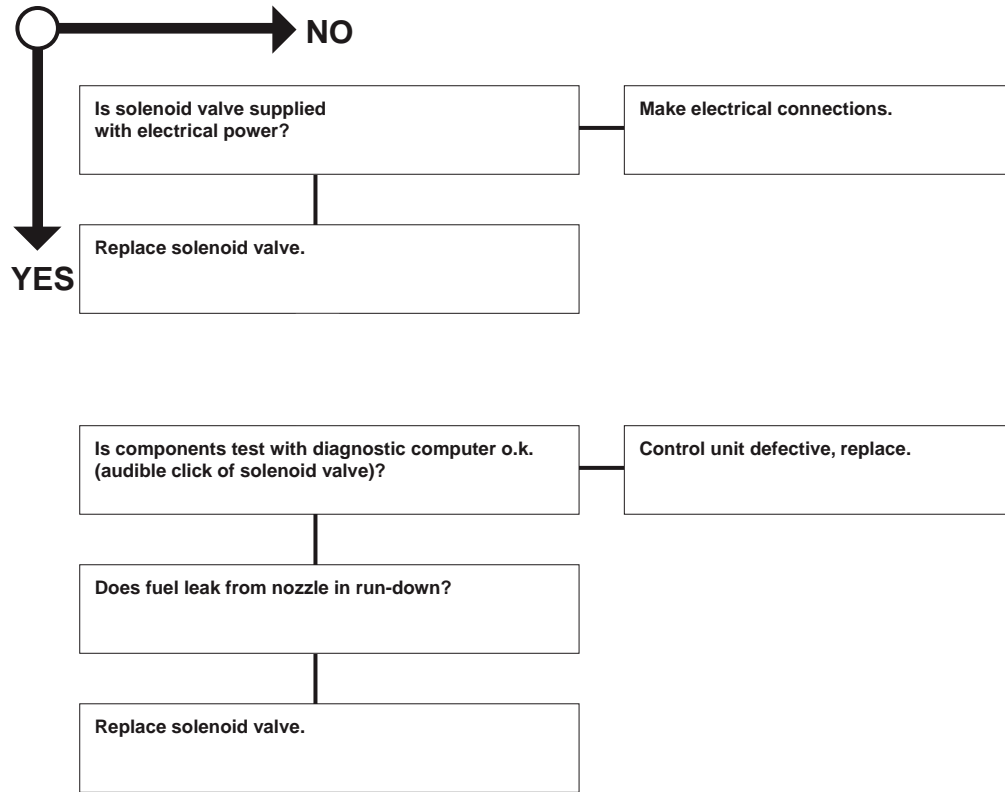
5.3.2.5 Fault Symptom "Flame Sensor Defective"



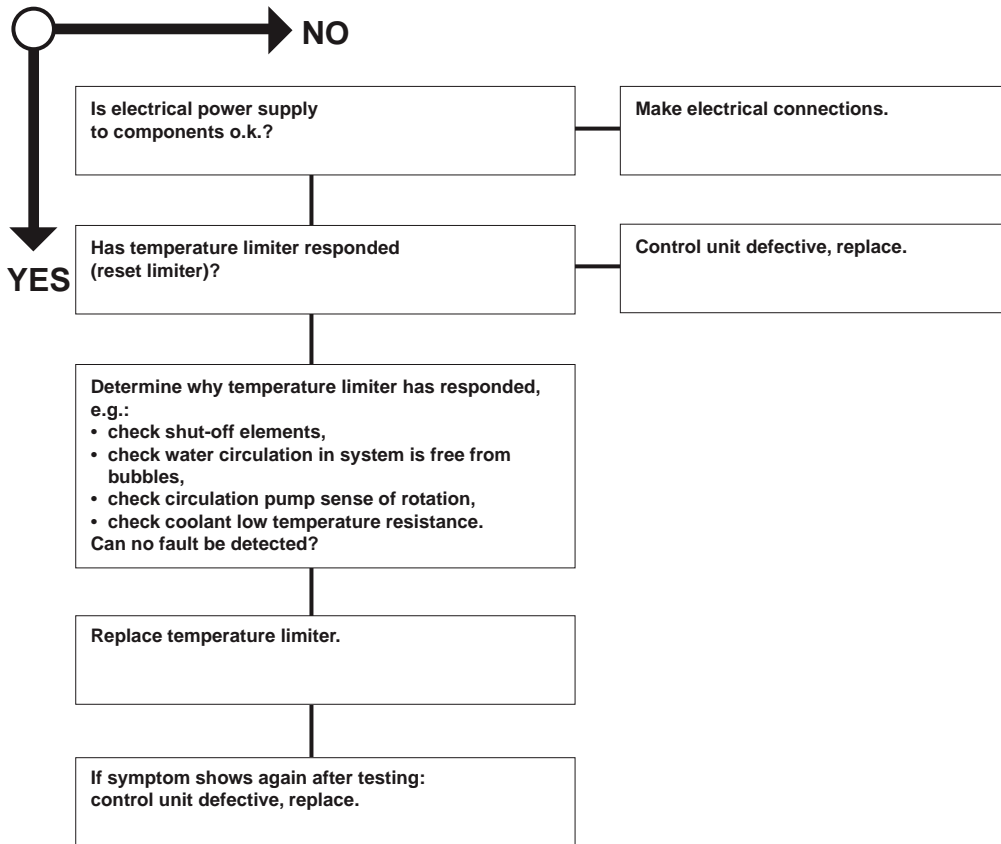
5.3.2.6 Fault Symptom "Temperature Sensor Defective"



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
The heater must not be operated in closed areas like garages or workshops with no exhaust ventilation facilities. To prevent fires do not switch heater on with burner swung open.

6.2 Adjustments

6.2.1 Adjustment of CO₂ Contents

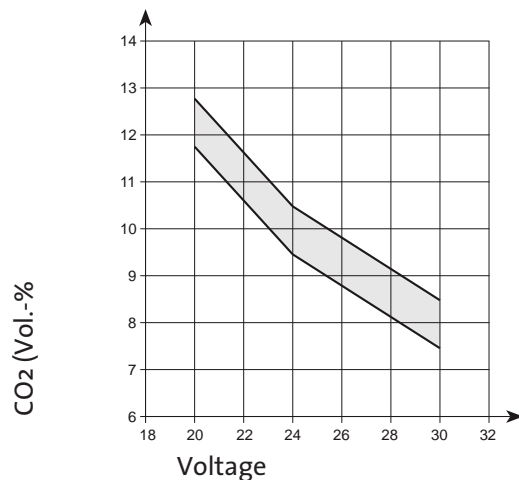
It is generally not necessary to change the factory setting for combustion air quantity during routine maintenance procedures. The heater comes from the factory preset and adjustment is not suggested unless the burner head has been rebuilt or its components have been replaced.

Adjustments may be necessary in the following cases:

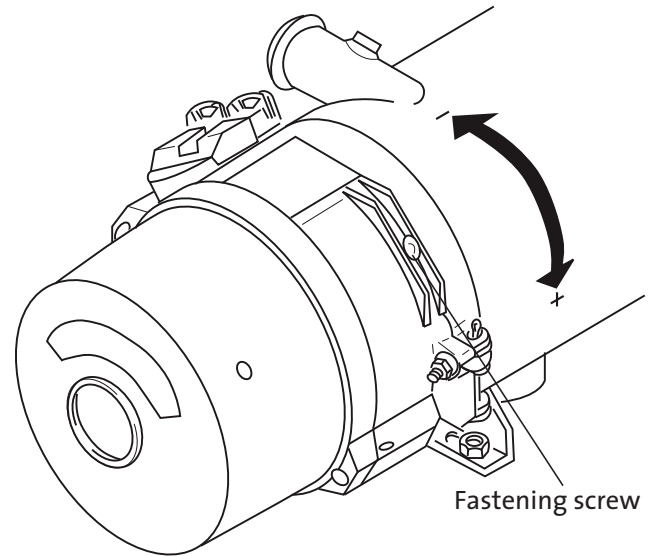
- repairs on the burner head
- nozzle replacement, air shutter, fuel pump (complete or partial rebuild)
- irregularities in combustion
- functional checkouts

Setting procedure

- measure control unit power supply voltage
- operate heater for approximately 5 min.
- measure CO₂ contents and smoke spot number and compare with relevant diagram



CO² - setting at 500 m



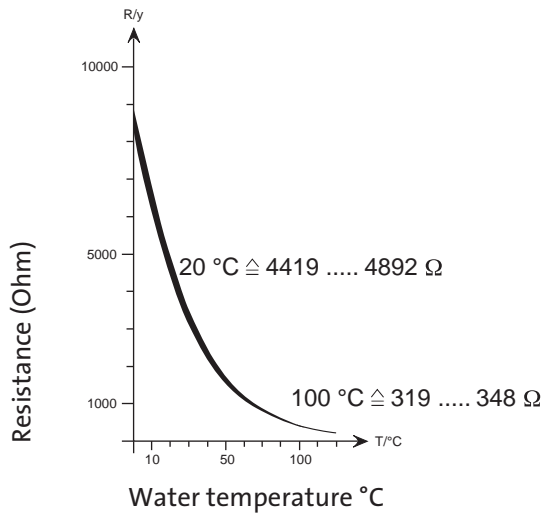
- loosen fastening screw (refer to Fig. above) and reposition setting ring with fastening screw until rated value is obtained.
- tighten fastening screw with 1.0 +0.5 Nm and apply screw seal varnish.

NOTE
CO ₂ setting depends on fuel (viscosity) and on geodetic altitude (0.1% per 100 m). If proper setting cannot be obtained or when exceeding smoke spot number, proceed as follows:
<ul style="list-style-type: none"> - check burner head air side for damage and replace if required - check fuel pump pressure and replace pump if required - check fuel filter and strainer in fuel pump for contamination and replace if required - adjust fuel pump pressure - 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 68° F (20° C) and approximately 212° F (100° C) (immerse sensor in water).



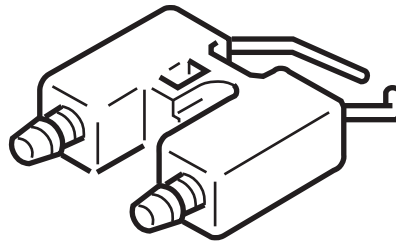
6.3.3 Igniter Electrodes Check

NOTE
The insulator of the igniter electrodes must show no damage. Igniter electrodes not working properly must be replaced.

Check

- inspect insulators of igniter electrodes for damage

CAUTION
In order not to disturb the fuel atomization do not touch nozzle bore when inspecting electrodes.

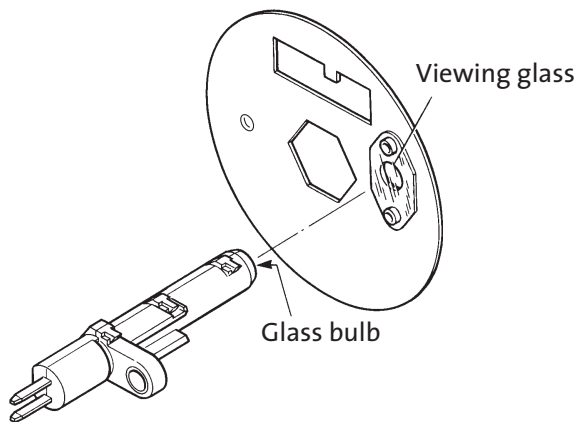


6.3.2 Flame Sensor Resistance Check

NOTE
The glass bulb of the flame sensor and the viewing glass of the window are to be cleaned if contaminated. In case of damage or not obtaining the rated value 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)



6.3.4 Electronic Ignition Coil Check

NOTE
The electronic ignition coil may also be tested using the PC heater diagnosis (component test).

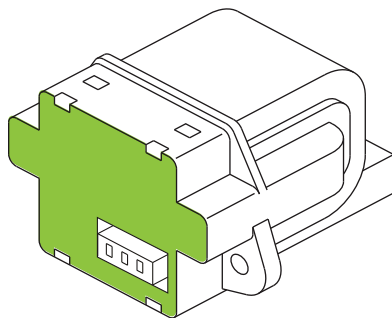
⚠ WARNING
High voltage; 20,000 volts arcing across the igniter electrodes.

⚠ CAUTION
Do not apply voltage to electronic ignition coil without electrodes.

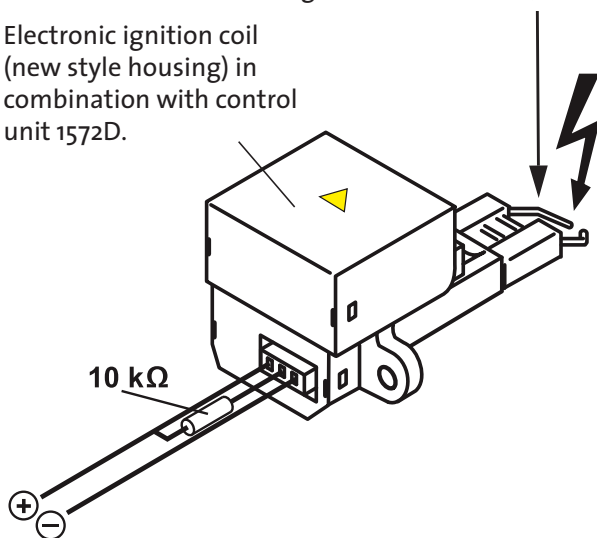
Check

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

NOTE Igniter electrodes 20,000 V
Electronic ignition coil (green connector cover) in combination with control unit 1572D.



NOTE Igniter electrodes 20,000 V
Electronic ignition coil (new style housing) in combination with control unit 1572D.

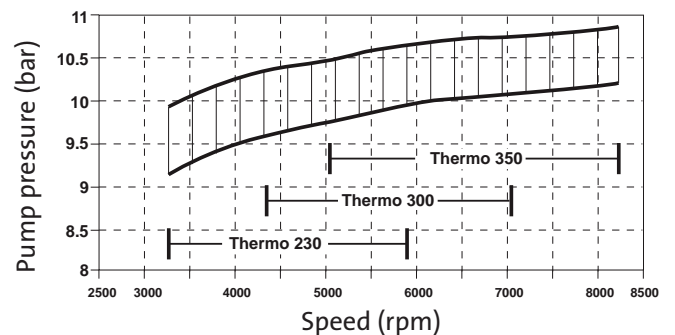
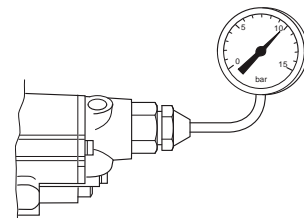


6.3.5 Fuel Pump Check

6.3.5.1 Fuel Pump Check on Heaters with Control Unit 1572D

NOTE
A test gauge is required for performing the test. Such a gauge (with a range from 0 to 15 bar or 200 psi) can be procured from your authorized Spheros dealer.
The fuel pump and fuel hoses must be replaced every 5 years.

⚠ CAUTION
Do not damage nozzle bore.
- screw in nozzle and torque to 20 Nm +2 Nm.
- Install electronic ignition coil (refer to 9.2.7.2).
- Do not operate heater without electrodes installed in coil.
- Fuel does accumulate in pressure gage as a result of the pressure test.
Use caution when removing gage as the fuel may still be pressured.



Pump pressure in relation to speed

6.3.5.2 Fuel Pump Check on Heaters with Control Unit 1572D

NOTE
On heaters with control unit 1572D the fuel pump may only be checked by means of the Spheros Thermo Test PC heater diagnosis.

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

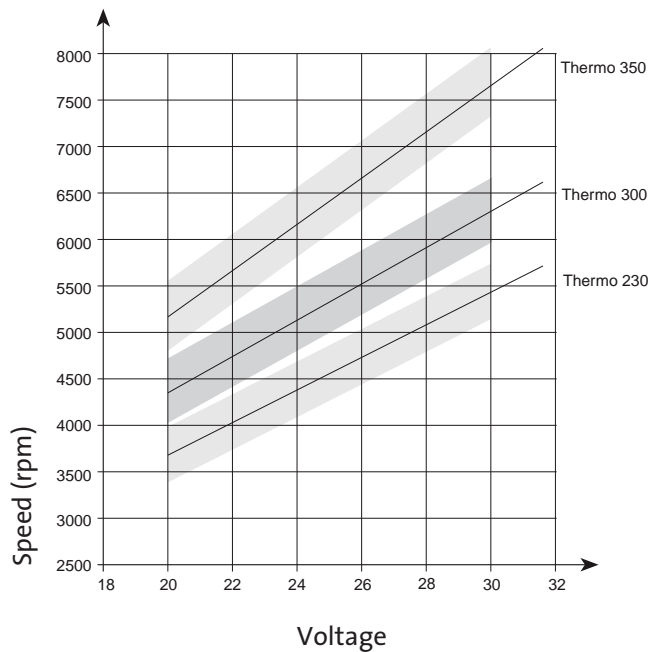
6.3.6 Drive Motor Check

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

Check

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

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



6.3.7 Solenoid Valve Check

NOTE
A solenoid valve with a leaking valve seat is indicated 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

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

- Check electric 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
With all variant of the control unit, the solenoid valve may also be checked by means of the PC heater diagnosis (component test).

6.3.8 Nozzle Block Pre-heater Check

NOTE
At a temperature of 32 °F (0 °C) the heater cartridge in the nozzle block is activated. The heating period depends on the heat reflected within the combustion chamber. Pre-heating is deactivated when the thermostat ambient temperature is 46 °F (+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 Ohm).

7 Circuit Diagrams

7.1 General

The circuit diagrams (Fig. 5 and Fig. 6) show possible heater circuits for Thermo 230, 300 and 350 with control unit 1572D and with

- switch
- standard timer 1531

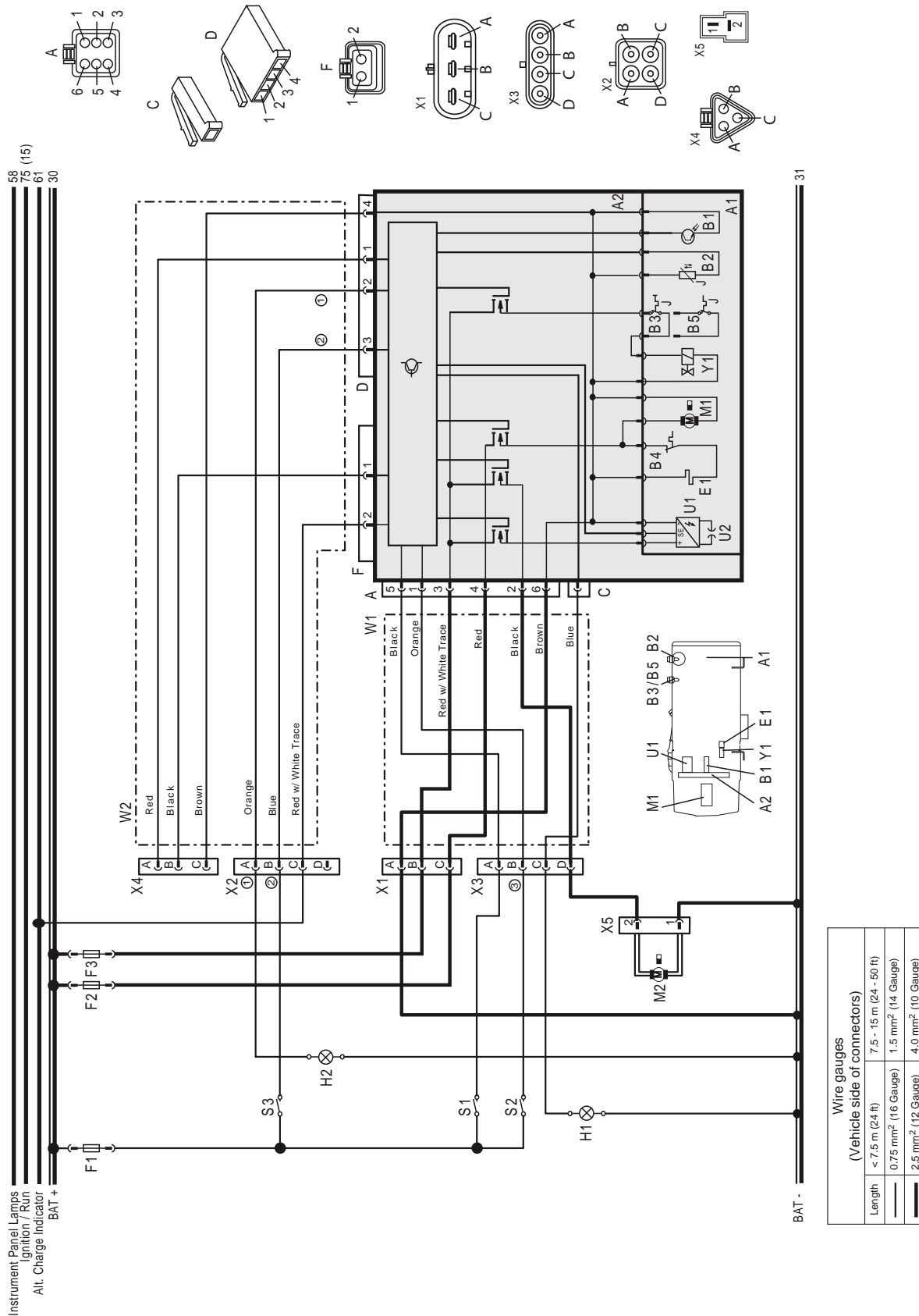


Figure 5: Automatic Control Circuit with Switch

Legend for Fig. 5 (previous page)

- ① Optional - flame indication light
- ② Optional - power save (pre-heating) signal
- ③ Optional - water pump run input (no heat)

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
B6	Thermostat	for vertical installation (MV Y1)
E1	Heating cartridge	for nozzle preheating
F1	Fuse 5A	flat fuse SAE J 1284
F2	Fuse 25A	flat fuse SAE J 1284
F3	Fuse 25A	flat fuse SAE J 1284
H1	Light	operation indicator light
H2	Light	flame indicator
M1	Motor	combustion air fan
M2	Motor	circulating pump
S1	Switch	on / off

Item	Nomenclature	Remark
S2	Switch	external trigger circulating pump
S3	Switch	power save operation
U1	Electronic Ignition Coil	
U2	Igniter electrodes	
W1	Wiring Harness (1)	
W2	Wiring harness (2)	
A	Plug connections, 6-pole	at control unit
C	Plug connections, 1-pole	at control unit
D	Plug connections, 4-pole	at control unit
F	Plug connections, 2-pole	at control unit
X1	Plug connections, 3-pole	main power / ground
X2	Plug connections, 4-pole	
X3	Plug connections, 4-pole	
X4	Plug connections, 3-pole	diagnostic connection
X5	Plug connections, 2-pole	water circulating pump
Y1	Solenoid valve	

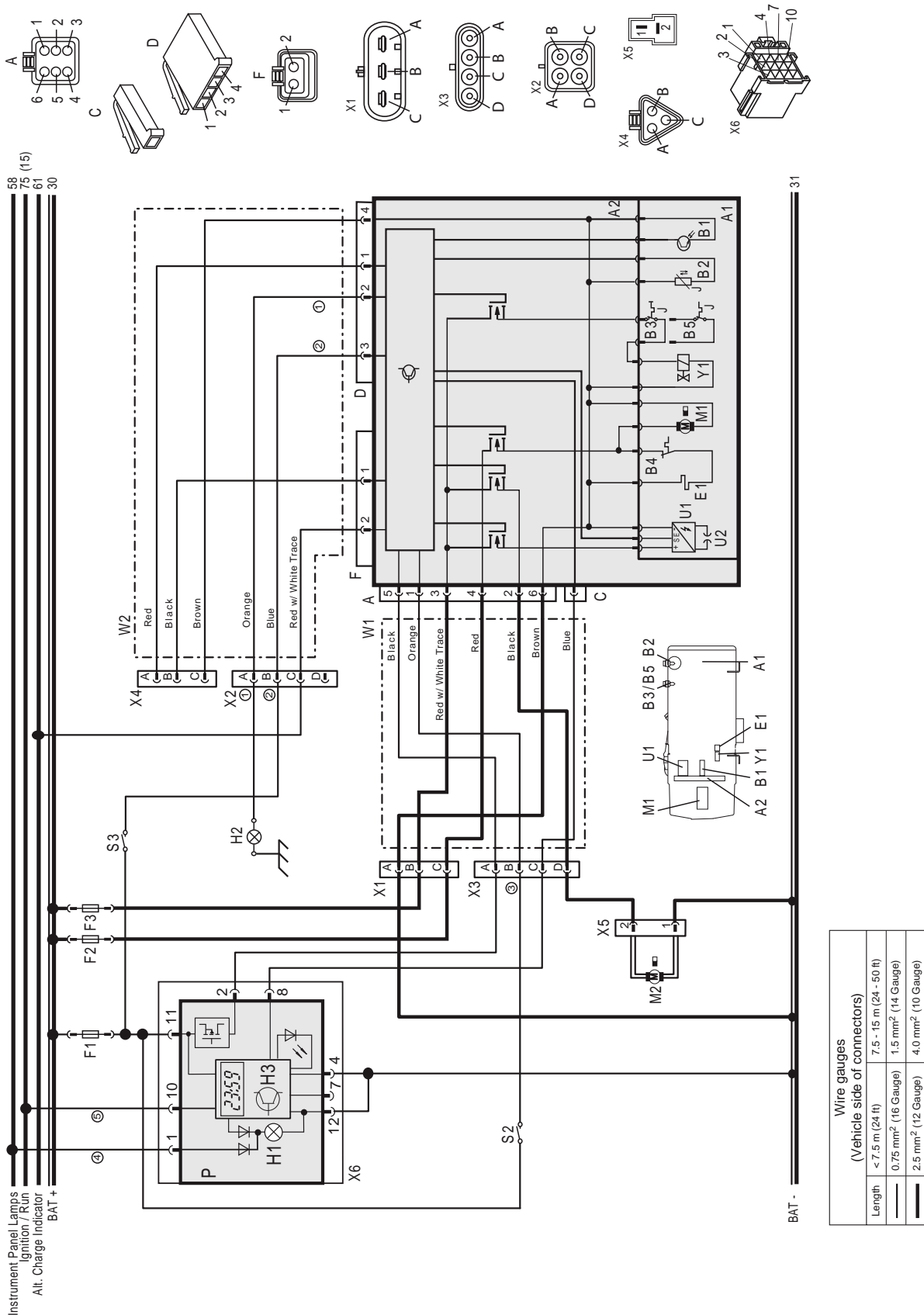


Figure 6: Automatic Control Circuit with Standard Timer 1531

Legend for Fig. 6 (previous page)

- ① Optional - flame indication light
- ② Optional - power save (pre-heating) signal
- ③ Optional - water pump run input (no heat)
- ④ Optional - connection to instrument panel lighting
- ⑤ Timer:
with plus to connection 10 = continuous operating during immediate heating
terminal 10 not connected = duration of heating programmable (10 min. to 120 min.)

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
B6	Thermostat	for vertical installation (MV Y1)
E1	Heating cartridge	for nozzle preheating
F1	Fuse 5A	flat fuse SAE J 1284
F2	Fuse 25A	flat fuse SAE J 1284
F3	Fuse 25A	flat fuse SAE J 1284
H1	Light	operation indicator light
H2	Light	flame indicator
H3	Symbol for "Heating" in Display	symbol lighting (in item P)
M1	Motor	combustion air fan
M2	Motor	circulating pump
P	Standard Timer (1531)	for timed operation

Item	Nomenclature	Remark
S1	Switch	on / off
S2	Switch	external trigger circulating pump
S3	Switch	power save operation
U1	Electronic Ignition Coil	
U2	Igniter electrodes	
W1	Wiring Harness (1)	
W2	Wiring harness (2)	
A	Plug connections, 6-pole	at control unit
C	Plug connections, 1-pole	at control unit
D	Plug connections, 4-pole	at control unit
F	Plug connections, 2-pole	at control unit
X1	Plug connections, 3-pole	main power / ground
X2	Plug connections, 4-pole	
X3	Plug connections, 4-pole	
X4	Plug connections, 3-pole	diagnostic connection
X5	Plug connections, 2-pole	water circulating pump
X6	Plug connections, 12-pole	Standard Timer 1531
Y1	Solenoid valve	

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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 major 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 vehicle manufacturer's instructions.

8.3 Vehicle Servicing

 CAUTION
In the vicinity of the heater a temperature of 230°F (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

To ensure functional reliability of the heater the following maintenance must be performed:

- check combustion air inlet and exhaust outlet for contamination and clean as required.
- outside the heating season the heater should be operated with the vehicle engine cold approximately every four weeks for 10 minutes setting the heating system to "warm". This avoids future difficulties when starting-up.
- at least once a year, in the case of contaminated fuel more often, the fuel filter or filter cartridge as well as the filter screen of the fuel pump must be replaced to avoid malfunctions.
- at least once a year the heat exchanger must be cleaned inside.

- in case of leakage the fuel pump and the fuel lines must be replaced immediately, otherwise every 5 years.
- the heater should be checked in regular intervals by a Spheros service agent or properly trained technician, the latest before the beginning of the heating season (refer to Annex A "Scheduled Maintenance"). When the heater is installed in rail vehicles, maintenance chart / test certificate item no. 90 087 22B is to be used.

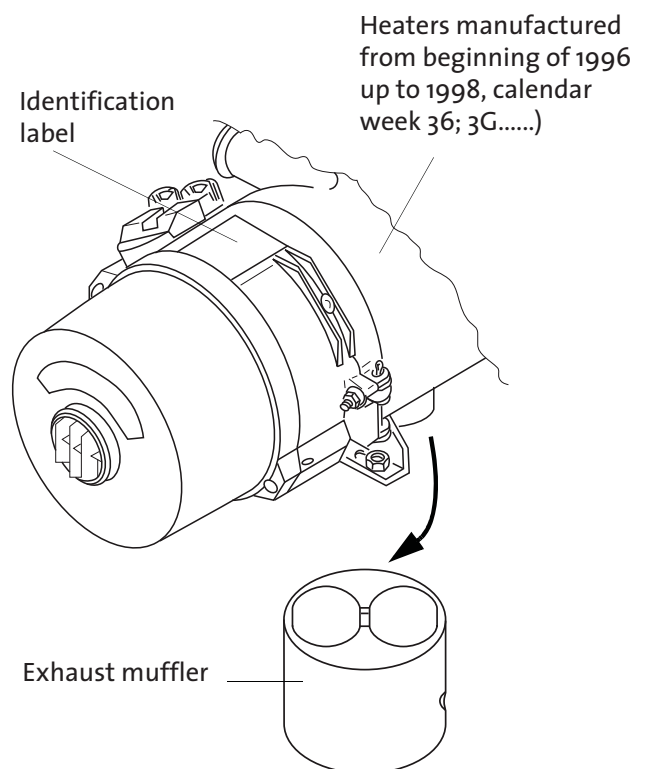
8.5.1 Inspection and Attachment of the Exhaust Muffler

(Only heaters from year of production 1996 and up to production date 1998, 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.



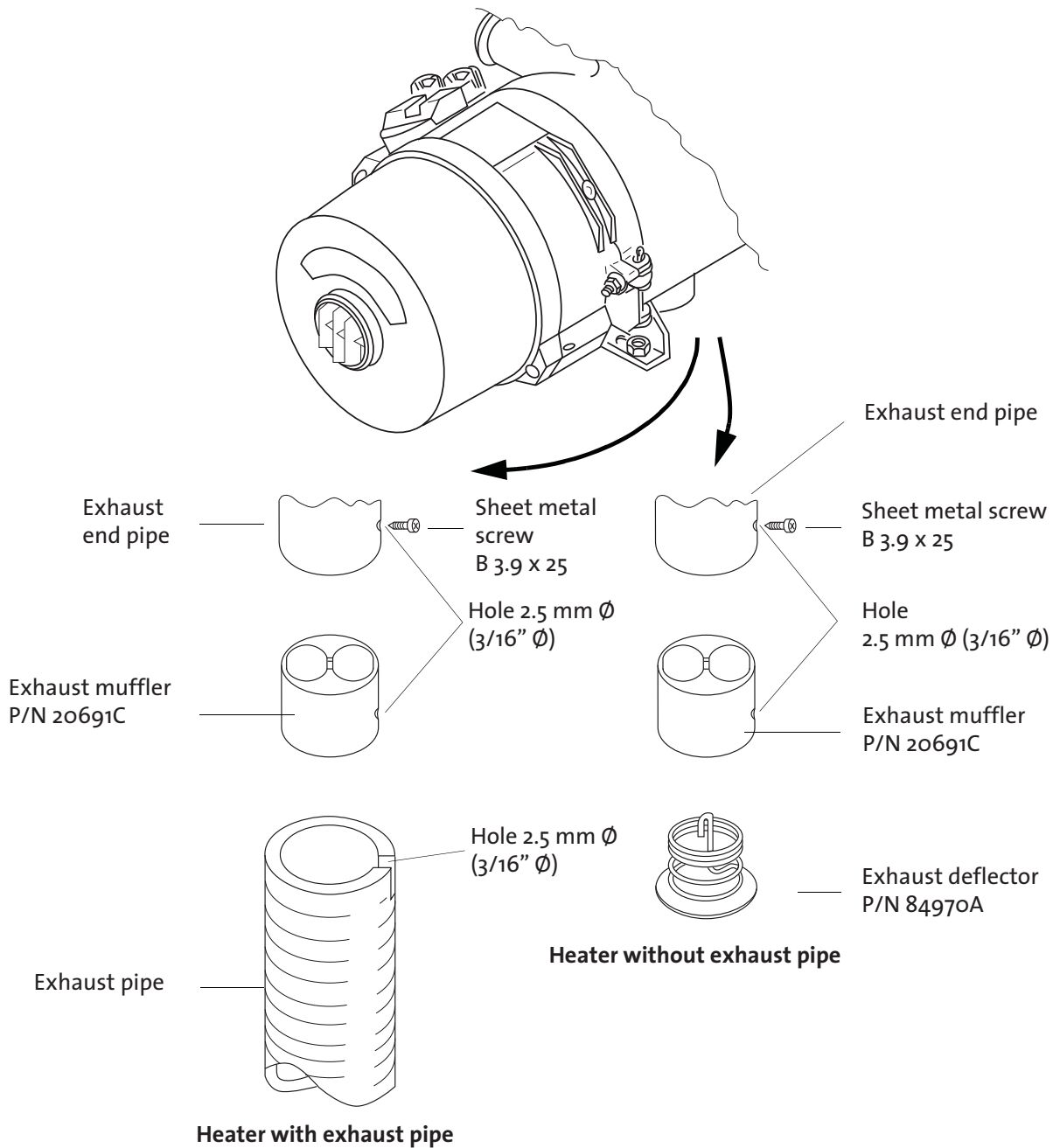
Inspection and Attachment

NOTE

The exhaust muffler must always be secured with a sheet metal screw. Drill a hole with a diameter of 3/16 in (2.5 mm) into the exhaust end pipe and muffler and secure 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 above. 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, secure muffler as described in NOTE above. Slot or drill exhaust pipe and refit.
4. If the exhaust muffler has been lost it may be ordered free of charge from Spheros (P/N 20691C). 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 (P/N 84970A) must be additionally fitted.



8.5.2 Burner Head Opening and Closing or Removal and Installation

⚠ WARNING

The electronic ignition coil 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 and securing burner head, reconnect connectors in the vehicle.

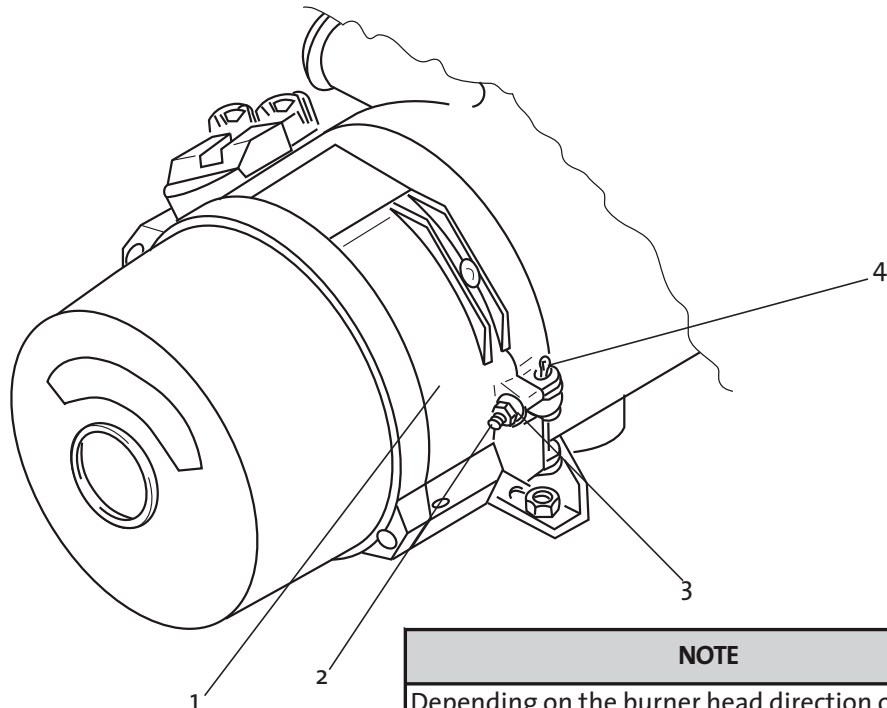
NOTE

Maintenance on the heater is easy. By swinging the burner head open the following components become accessible:

- fuel pump and fuel nozzle
- solenoid valve
- electronic ignition coil
- igniter electrodes
- flame sensor
- combustion chamber
- nozzle block pre-heater (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.

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



Opening or removal

1. Disconnect electrical connections to temperature limiter and temperature sensor.
2. Loosen nuts (2, Fig. 7) enough to release hinge bolts (1).
3. Swing hinge bolts (1) out.
4. Swing burner head (3) open.
5. Remove cotter pin (1) as required to remove burner head.

Closing or installation

1. As required for installation, fasten burner head (4, Fig. 8o1) in position using cotter pin (1)
2. Swing burner head (4) closed and locate for assembly.
3. Swing hinge bolts (2) into lock position and secure with nuts (3).
4. Torque nuts (3) to 7,5 Nm + 1 Nm.
5. Reconnect electrical connections to the temperature limiter and temperature sensor.

NOTE

When making electrical connections observe wiring color codes.

NOTE

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

Figure 7: 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 circulating pump. This applies in particular for the circulating pump because it is not self-priming.

The heater is to be connected to the vehicle cooling system according to Fig. 8. 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

Hose clamps must be torqued with 1.5 Nm+0.5 Nm.

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 circulating pump almost noiseless in operation.

When using the circulating pump U4855, U4856 the circulating pump automatically switches off approx. 15 seconds after switch-on should coolant be

missing or the pump wheel be seized. After 2 minutes the pump may be reactivated.

In combination with control unit 1572D (Thermo label colored) and with programmed circulating 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 disconnection 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 73379-1C; type 3. Fuel hoses must not be kinked or twisted and must be secured with clamps every 1 in (25 mm).

Fuel lines 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) may also be used according to DIN 73378 observing the applicable jointing instructions.

Basic rules for the routing of fuel lines are:

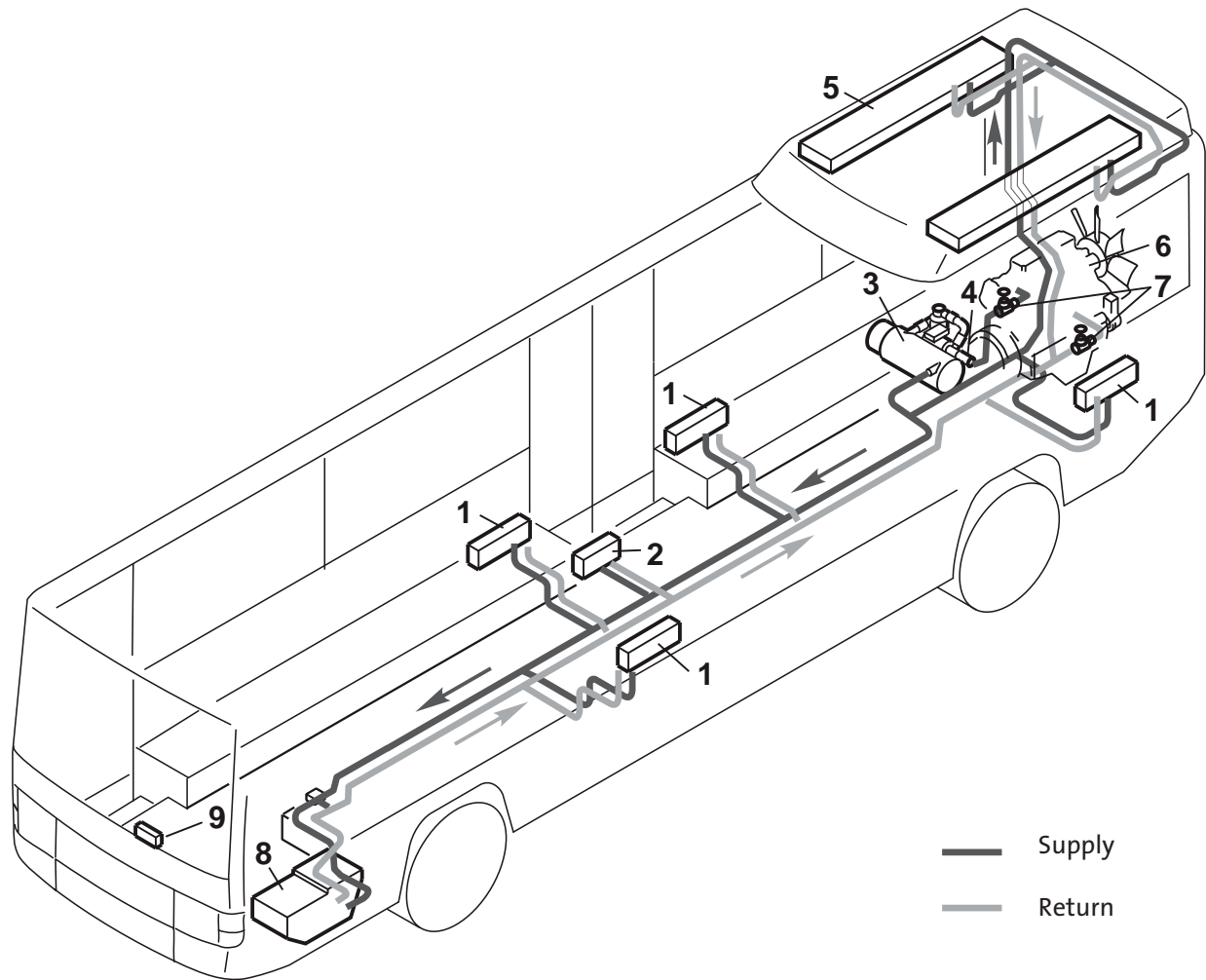
- Protect against undue temperatures.

⚠ WARNING

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

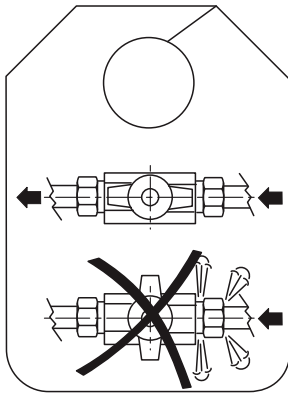


- 1 Sidewall heat exchanger with fan
- 2 Stepwell heat exchanger with fan
- 3 Spheros Heating unit
- 4 Circulating pump
- 5 Heat exchanger, roof
- 6 Vehicle engine
- 7 Water valves
- 8 Driver area heat exchanger / defroster
- 9 Control device (Timer and/or Switch)

Figure 8: Example of a Heater Installation in a Transit Bus

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

! CAUTION
Operation with the return line shut off causes damage to the fuel pump. Fuel may escape. Danger of fire.
The heater must be electrically disabled by disconnection of the main power supply whenever the return line is blocked!



Example of 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:
- 1/4 in (6 mm) (other diameters upon request).
- max. permissible length for each suction and return line: 33 ft (10 m)
- Max. permissible suction height: 6.5 ft (2 m). (installation of a bottom valve is recommended for max. suction height)
- Max. permissible priming pressure: 0.3 bar for suction and return line.

8.6.2.2 Fuel Filter

A fuel filter supplied as deliverable item or cleared for use by Spheros is to be fitted. 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

! CAUTION
Observe official regulations concerning the installation (see 1.6).
Combustion air must under no circumstances be extracted from rooms with persons. 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: 2-3/16 in (55mm)
- max. length: 16.5 ft (5m)
- 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 to the heater, a water drain hole \varnothing 1/8 in (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	4.5 in ² (30 cm ²)
Thermo 350	5.4 in ² (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

! CAUTION
Observe official regulations concerning the installation (see 1.6).
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 1/32 in (1 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: 2.75 in (70mm)
- max. length: 16.5 ft (5m) without exhaust extension
- max. bend: 270°

As an alternative an exhaust deflector must be installed cleared 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 electronic ignition coil
- 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 circulating 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 to 1.5 Nm. Open water cocks.
4. Connect fuel supply and return lines and tighten connections or screw tight with banjo bolt and new copper gaskets.
5. Secure combustion air inlet line on heater as applicable.
6. Connect electrical connectors of cable harness in vehicle and to circulating 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.

 WARNING
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
The electronic ignition coil operates on high voltage. Prior to replacement of burner disconnect electrical connectors of cable harness in vehicle to avoid lethal accidents.

8.7.5 Electronic Ignition Coil, Replacement

The replacement procedure for the electronic ignition coil is identical with the heater installed or removed. Perform replacement in accordance with 9.2.8.

⚠ WARNING
The electronic ignition coil operates on high voltage. Prior to replacement of electronic ignition coil 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
The electronic ignition coil operates on high voltage. Prior to replacement of flame sensor 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
The heater operates on high voltage. Prior to replacement of combustion chamber 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 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 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 circulating pump must not be switched on.

Set vehicles own heating system to "warm" and replenish coolant which must consist of at least 20% glycol based anti-freeze (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.

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 by pushing 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. In this case, allow time for heater to cool down and limiter to self-reset.

8.8.2 Fuel Supply System, Bleeding

When switching the heater on, the fuel pump draws fuel to prime the complete fuel supply system.

Should no combustion be achieved with the first start attempt, switch the heater off and on again.

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 service part kits are to be used.

 **WARNING**

The electronic ignition coil operates on high voltage. The following components may also be replaced with the heater installed unless restricted space prevents access:

- temperature limiter
- temperature sensor
- combustion air fan
- burner
- electronic ignition coil
- flame sensor
- combustion chamber

Prior to replacement disconnect connectors of cable harness in vehicle to avoid lethal accidents.

 **WARNING**

Hot coolant may escape during the replacement of the temperature sensor. Before replacing the temperature sensor also release pressure from cooling system by opening coolant system pressure cap. If required, also allow heater to cool down.

9.1.1 Work on Components after Disassembly

 CAUTION
All gaskets located between disassembled components must always be replaced and old gaskets 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 3 in (80mm) 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.

 CAUTION
When replacing the combustion chamber on heaters installed vertically, remove carbon deposits in heat exchanger using a suitable tool.

9.1.1.4 Combustion Air Fan Rotor, Visual Inspection

- Check fan rotor for contamination and cracks.
- Check cover plate for security.
- Check slide lock for proper seating.

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 circulating pump U 4855 or U4856 as substitute for circulating pump U4816. (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:

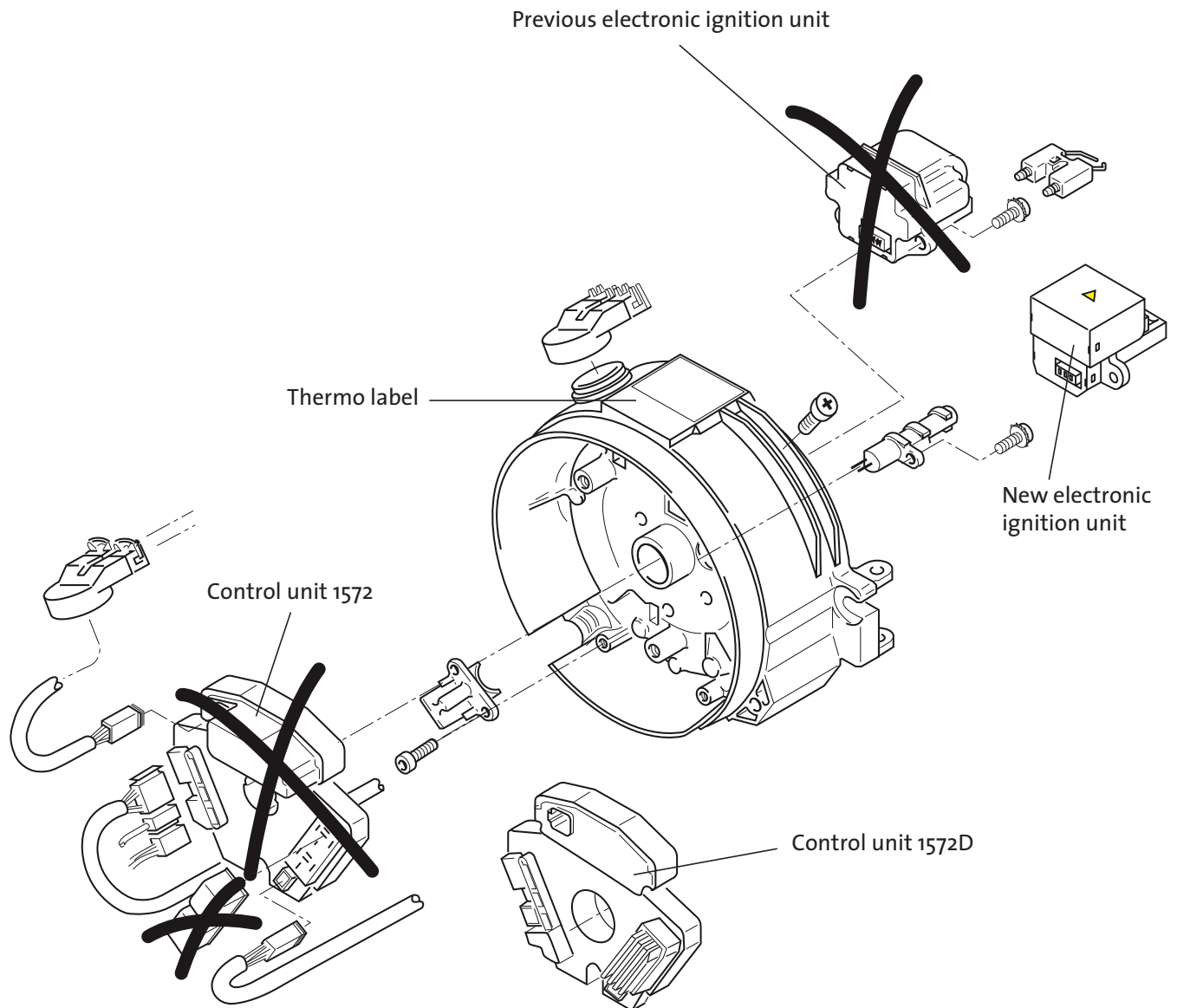
The modification kit consists of:

- control unit 1572D
- electronic ignition coil
- thermo identification label

Procedure

 CAUTION
Control unit 1572D may only be used in combination with the electronic ignition coil delivered (green connector cover). The electrical connector is coded.

1. Remove control unit according to 9.2.5.1 and discard.
2. Remove electronic ignition coil according to 9.2.8.1 and discard.
3. Install new electronic ignition coil 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.



9.1.2.2 Installation of Circulating Pump Aquavent 5000/ 5000s or 6000 as substitute for Circulating Pump U 4816

General

The circulating pumps U 4816 may be substituted by circulating pump Aquavent 6000C (U 4855) Aquavent 6000CS (U 4856).


When exchanging circulating pump U 4816 the attachment parts (mount and hose clamp) may be re-used.

An adaptation of the water connection is not necessary. The same applies for compact units.

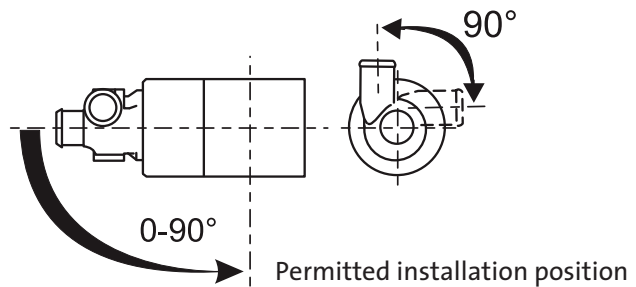
When exchanging circulating pump U 4814 observe the following:


- The existing mount and hose clamp must be removed and discarded. Installation must be performed using a new mount and hose clamp.
- When mounting the circulating pump near to a wall, the new mount must be attached so that there is a clearance of 2-3/8 in (60 mm) to the wall (reference line: circulating pump centerline). If required, the new mount must be relocated in relation to the old mount.
- Hose connections must be adapted.
- If the circulating pump is mounted into a compact unit, the exchange procedure is difficult and must be checked if practicable.

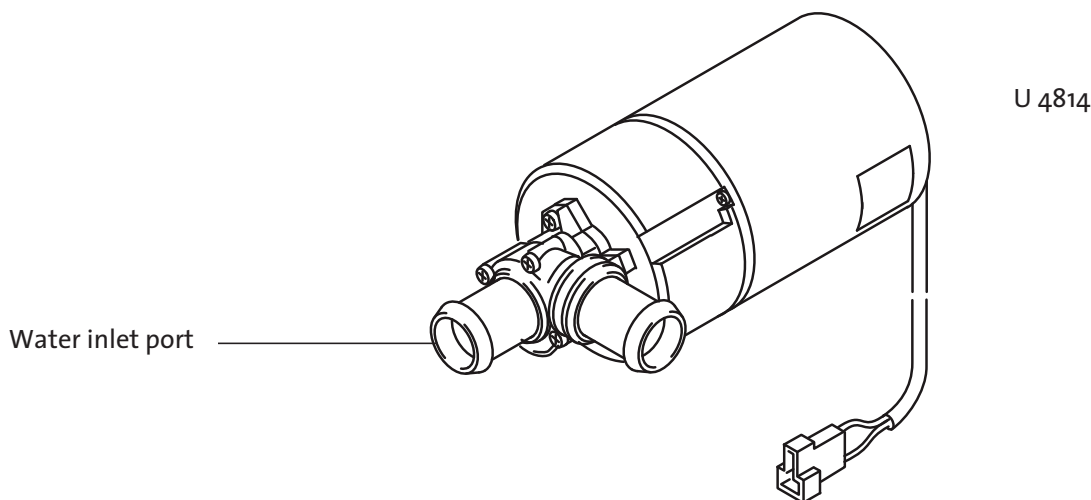
Procedure, circulating pump Aquavent 5000 (U 4814) Aquavent 6000C (U 4855)

 CAUTION
When installing circulating pump U 4814 and U4855 the following information must be strictly observed to avoid loss of warranty.

NOTE
<ul style="list-style-type: none"> • The circulating pump is not self-venting of any accumulating air. Therefore the pump has to be installed at the lowest point of the water circuit observing the permitted pump orientation (see Fig.). • The hoses must be installed routed upwards free of kinks. Hose connections must be secured against slippage with hose clamps. The tightening torque specification of the clamps used must be complied with. • On the water inlet side of the pump no solenoid valves or other shut-off devices must be installed allowing closure during pump operation. The same applies for filters which may clog. • Prior to first operation of the circulating pump, the vehicle cooling system and the pump body must be bled.



 CAUTION
Improper bleeding or a dry run of the pump causes damage to the slip ring seal. Proper bleeding may be verified by almost noiseless operation of the pump.



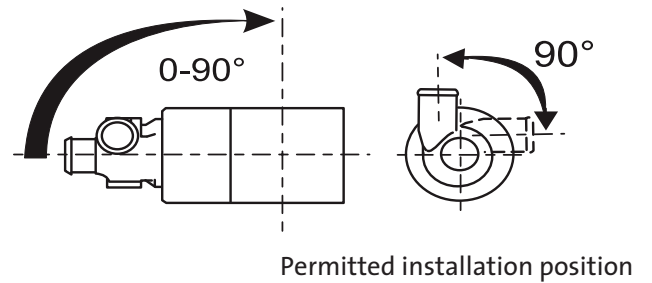
**Procedure, circulating pump Aquavent 5000S (U 4854)
Aquavent 6000SC (u 4856)**

CAUTION
When installing circulating pump U 4854 and U 4856, the following information must be strictly observed to avoid loss of warranty.

NOTE

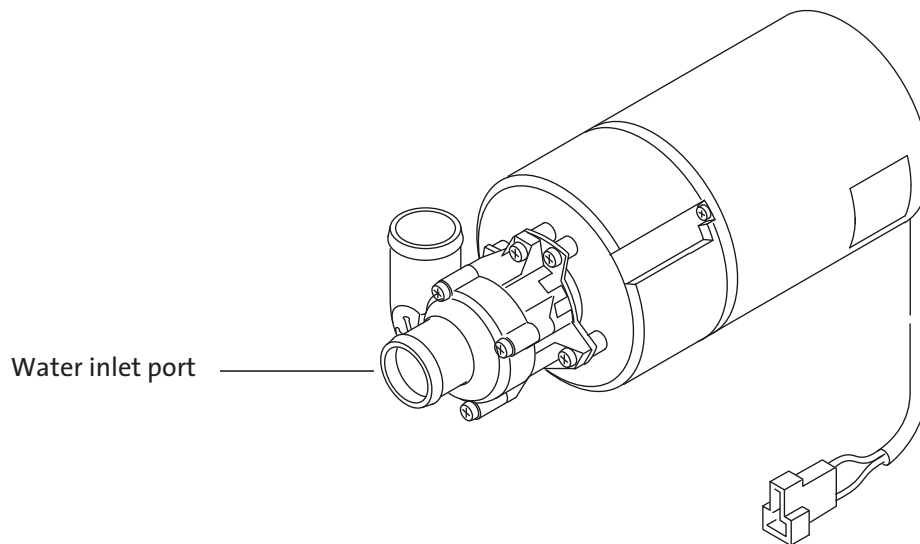
- Different to the U 4814, the U4854 and U 4856 can be installed in the vertical position so that the pump head is located above the motor.
- The circulating pump is not self-venting of any accumulating air. Therefore the pump has to be installed at the lowest point of the water circuit observing the permitted pump orientation (see Fig.).
- The hoses must be installed routed upwards free of kinks. Hose connections must be secured against slippage with hose clamps. The tightening torque specification of the clamps used must be complied with.
- On the water inlet side of the pump no solenoid valves or other shut-off devices must be installed allowing closure during pump operation. The same applies for filters which may clog.

- Prior to first operation of the circulating pump, the vehicle cooling system and the pump body must be bled.
- The Aquavent 6000 SC pump head includes no parts subject to wear. A motor replacement, in some cases, is possible without removal of the pump head from the circulation system.



CAUTION
A dry run of the Aquavent 6000 SC circulating pump is permitted up to 15 minutes. Proper bleeding may be verified by almost noiseless operation of the pump.

Aquavent 5000S



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. 9).

9.2.1.2 Installation

1. Slide rubber cap of temperature limiter (1, Fig. 9) back until temperature limiter can be located for installation.
2. Position temperature limiter (1) in connector (3) and push in retaining clip.

NOTE
The retaining spring must be located in the groove of the housing and must be latched 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. Fit rubber cap.
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.

 WARNING
Prior to replacement of temperature sensor in installed condition, relieve coolant pressure in cooling system by

opening the coolant circuit pressure cap. If required, also allow heater to cool down and have collector vessel ready to collect escaping coolant.

2. Unscrew temperature sensor (2, Fig. 9) and remove.

9.2.2.2 Installation

1. Manually screw temperature sensor (2, Fig. 9) into coolant outlet (4).
2. Torque temperature sensor to 20 Nm +5 Nm.
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 supply and return line connections, disconnect and fit dummy plugs.
2. Loosen nuts (6, Fig. 9) 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. 9) 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) to 7.5 Nm + 1 Nm.
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

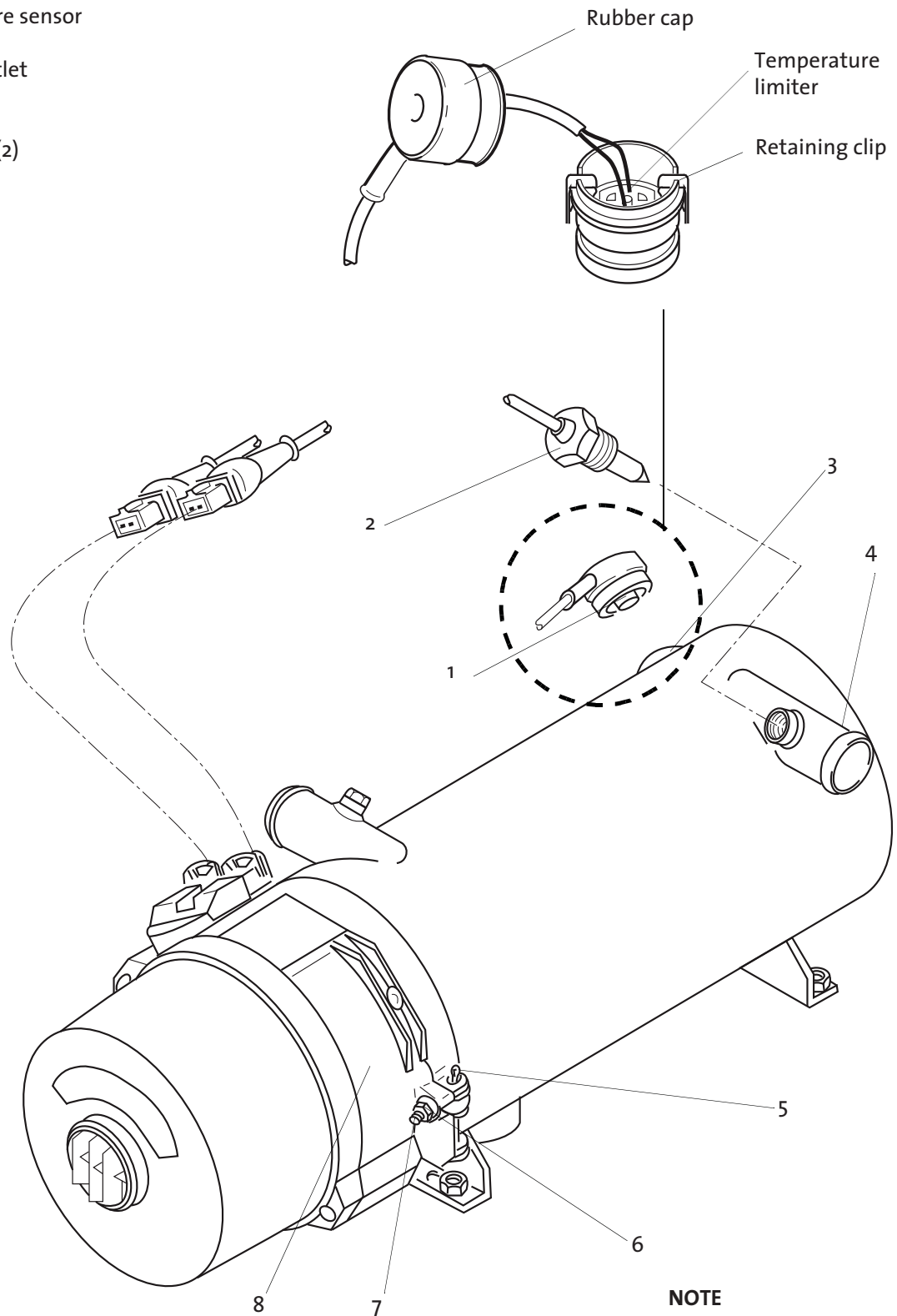


Figure 9: Temperature Limiter, Temperature Sensor and Burner, Replacement

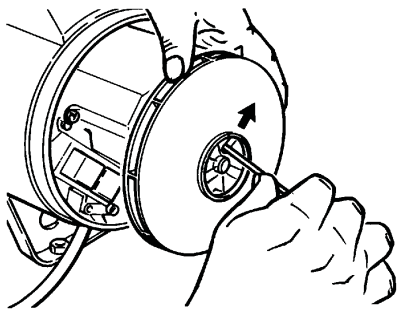
9.2.4 Combustion Air Fan and motor Replacement

NOTE

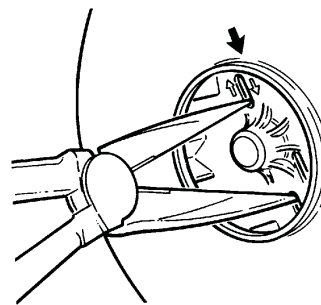
For replacement of the combustion air fan and motor, the burner may be left installed. In removed condition ensure that igniter electrodes are not bent and nozzle is not damaged.

9.2.4.1 Removal

1. Loosen screws (3, Fig. 10) and withdraw cap (2) from burner.
2. Using suitable tool (e.g. 1/8" pin punch) open slide lock (5) until fan rotor can be pulled off.
3. Disconnect electrical connector (9).
4. Remove screws (6) with lock washers and withdraw drive motor (7).
5. Perform procedures on components after disassembly (refer to 9.1.1).



Opening slide lock



Closing slide lock

9.2.4.2 Installation

NOTE

Drive motor (7, Fig. 10) to be aligned with control unit (recess in mounting flange) and with clutch (by rotating drive shaft).

1. Align drive motor (7) and position for installation.
2. Attach drive motor using screws (6) and lock washers.
3. Tighten screws to 5 Nm + 1 Nm.
4. Connect electrical connector (9).
5. Bring slide lock (5) on fan rotor in installation position.
6. Slide fan rotor onto drive shaft and using suitable tool (e.g. 1/8" pin punch or pliers) close slide lock until fan rotor is locked.
7. Locate cap (2) and secure with screws (3).
8. Tighten screws to 2 Nm + 0.5 Nm.

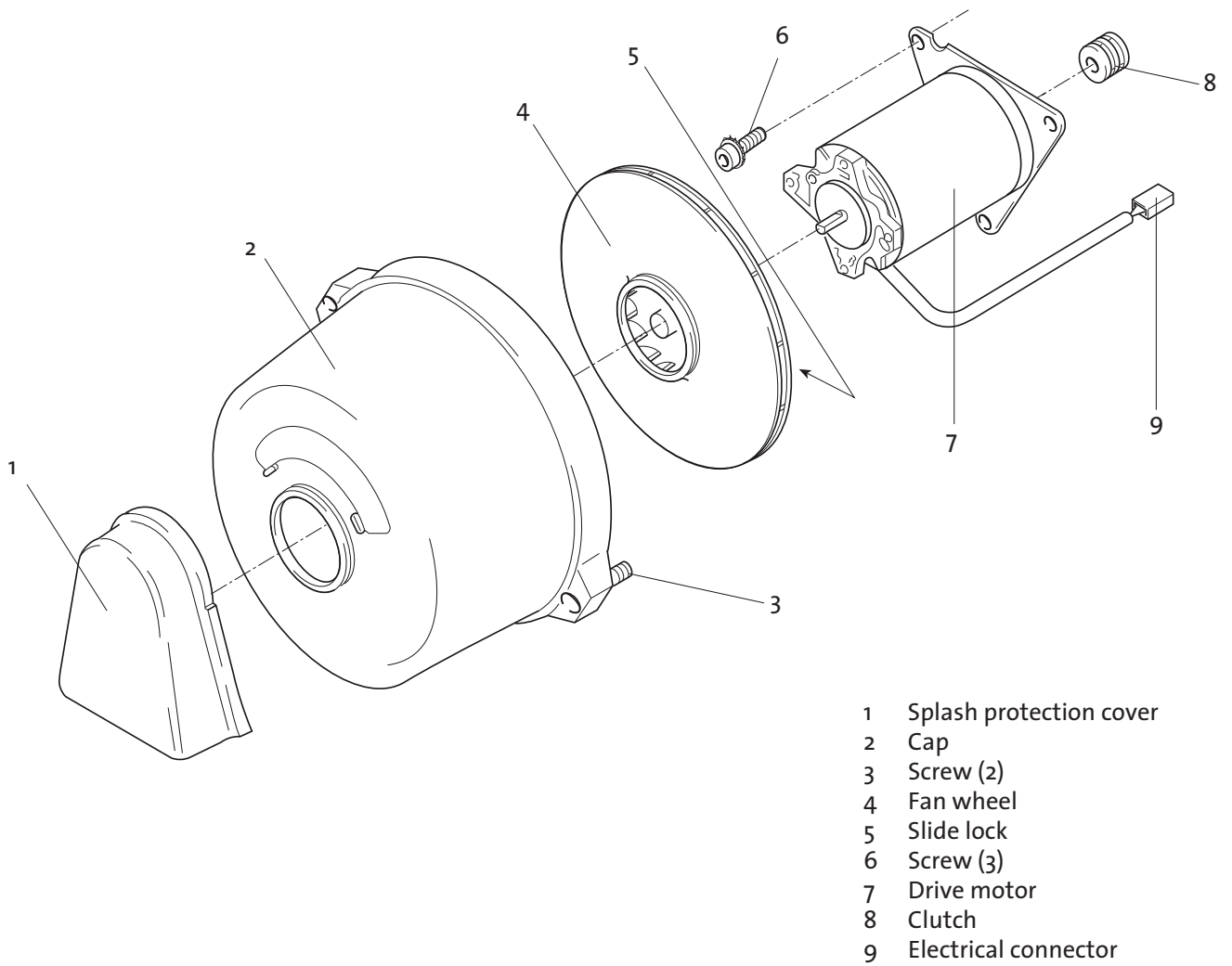


Figure 10: Combustion Air Fan, Replacement

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. 11).

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. 11).
2. Swing burner head open (refer to 8.5.2) and disconnect electrical connector (8) of fuel solenoid and, if equipped, nozzle preheat (24).
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 install control unit (23, Fig. 11) in axial direction into burner head (17) until fully seated.
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) of fuel solenoid and, if equipped, nozzle preheat (24).

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 (1, Fig. 12) from electronic ignition coil (2) and remove.
3. Remove disk (6, Fig. 11) and nozzle pre-heating cartridge (if installed) from pump (10).
4. Disconnect electrical connector (8) of fuel solenoid.

NOTE

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

5. Remove screws (9) with lock washers.

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

9.2.6.2 Installation

1. Install solenoid valve (7, Fig. 11) 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 screws (9) and lock washers.
4. Tighten screws to 5 Nm + 1 Nm.
5. Connect electrical connector (8) of fuel solenoid.
6. Install heating cartridge and place disk (6) into position.
7. Plug in igniter electrodes (3, Fig. 11).
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. 11) from electronic ignition coil (1) and remove.
3. Remove disk (6, Fig. 11) with nozzle pre-heating thermostat (if installed) from pump (10).
4. While holding the nozzle holder with an 18 mm wrench, remove nozzle (4) with a 16 mm wrench or socket.

NOTE

Ensure cleanliness is maintained when installing the nozzle. Only touch the nozzle by its hexagon surface.

9.2.7.2 Installation

1. While holding the nozzle holder with an 18 mm wrench, screw in nozzle (4) and tighten with a 16 mm wrench or socket. Tighten nozzle to 20 Nm.
2. Place disk (6, Fig. 11) with nozzle pre-heating thermostat (if installed) into position on pump (10).
3. Plug in igniter electrodes (3, Fig. 11).
4. Install burner (refer to 9.2.3.2).

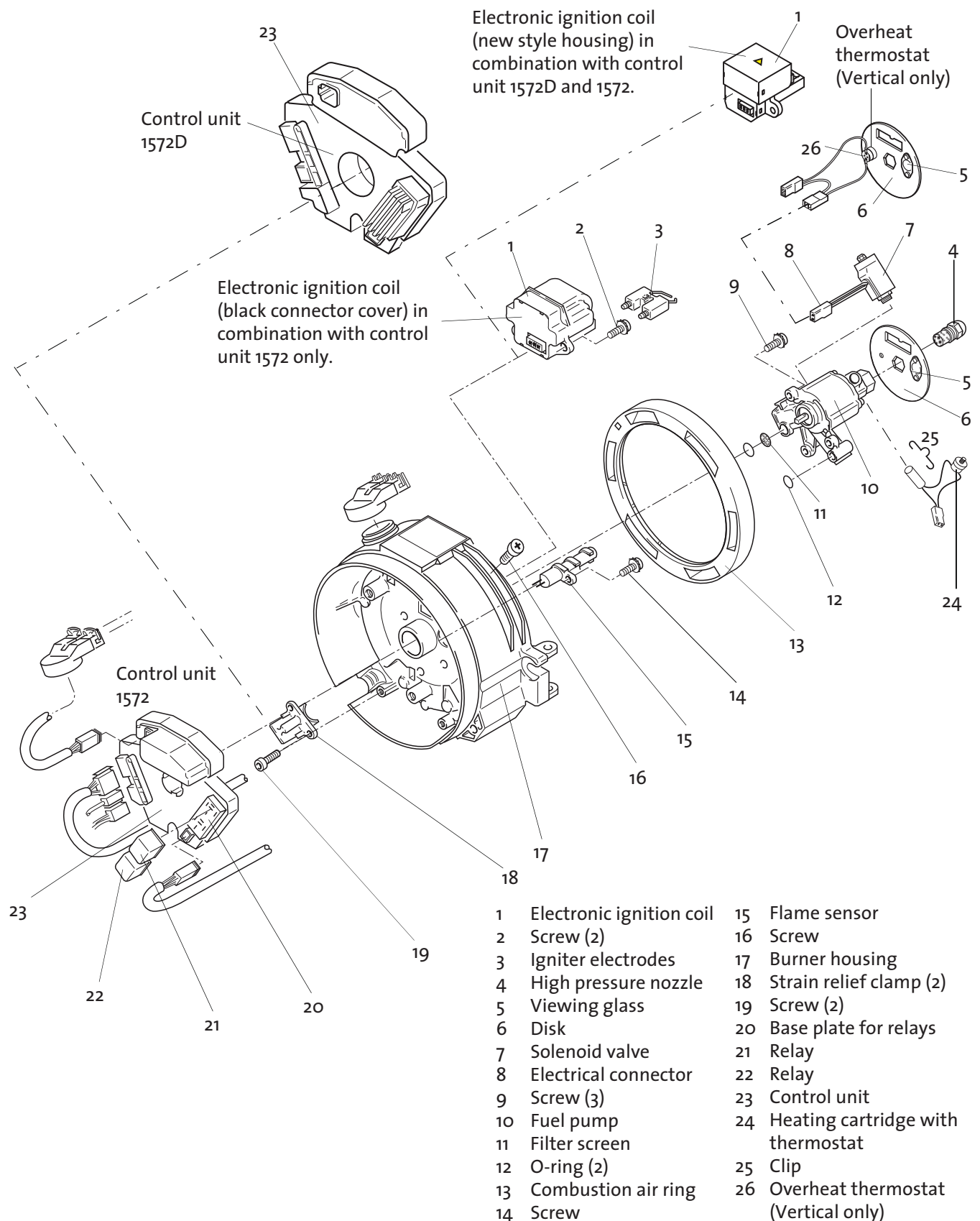


Figure 11: Control Unit and Fuel Pump, Replacement

9.2.8 Electronic Ignition Coil, 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. 12) from electronic ignition coil and remove.
3. Remove disk (6).
4. Remove screws (2) with lock washers.
5. Withdraw electronic ignition coil (1) and remove.
6. Perform procedures on components after disassembly (refer to 9.1.1).

9.2.8.2 Installation

1. Locate electronic ignition coil (1, Fig. 13) for installation, plug in making correct electrical connections and secure with screws (2) and lock washers.
2. Tighten screws (2) to 5 Nm + 1 Nm.
3. Position disk (6) and align.
4. Plug in 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. 12) from electronic ignition coil 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. 13) for installation, plug in to make correct electrical connections and secure with screw (14) and lock washer.
2. Tighten screw (14) to 5 Nm + 1 Nm.
3. Position disk (6) and align.
4. Plug in igniter electrodes (3).
5. Install burner (refer to 9.2.3.2).

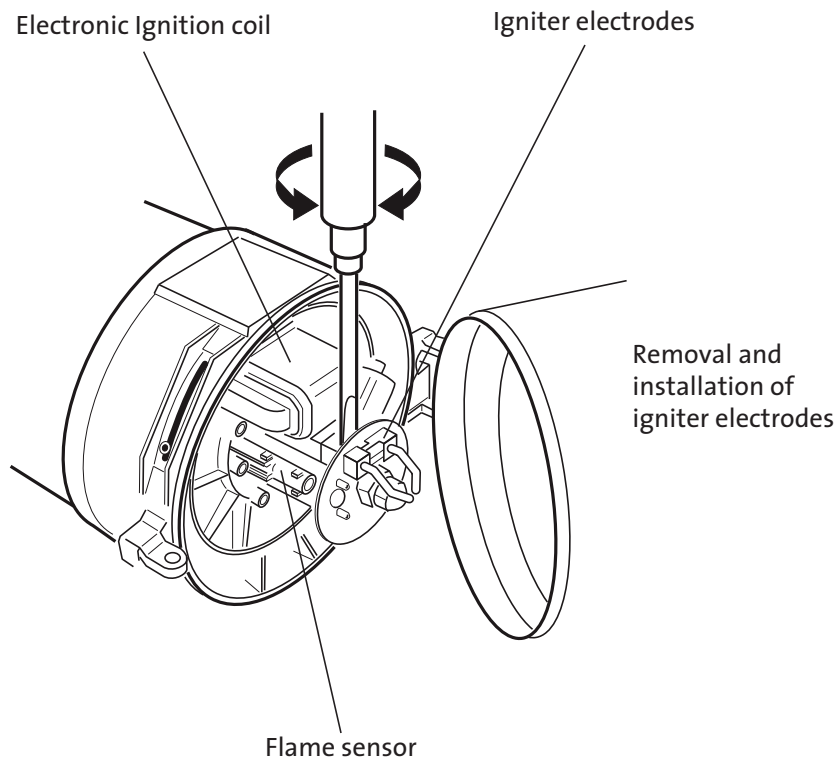


Figure 12: Electronic Ignition Coil and Flame Sensor, Replacement (Sheet 1 of 2)

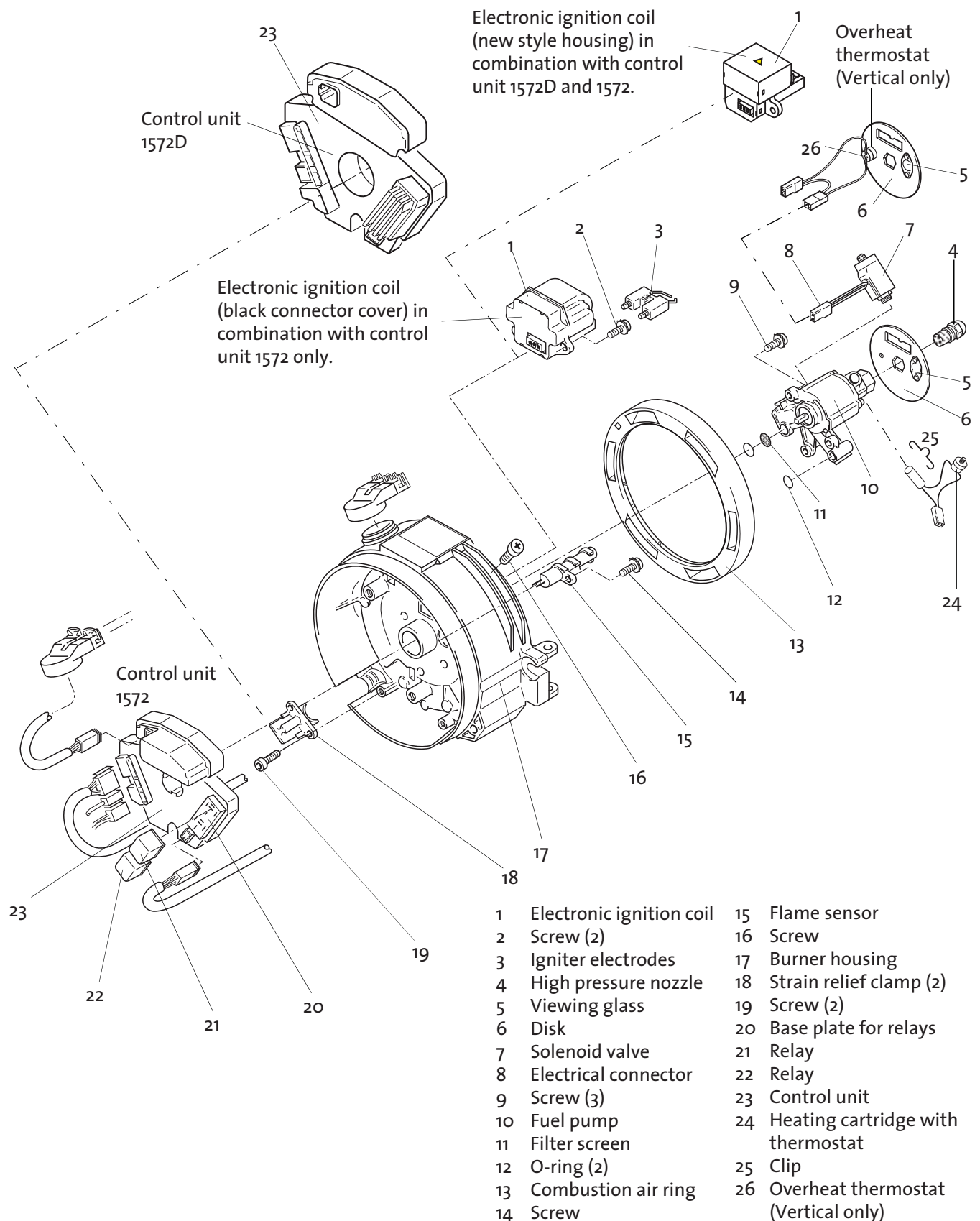


Figure 13: Electronic Ignition Coil and Flame Sensor, Replacement (Sheet 2 of 2)

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. 14) 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. Slide combustion chamber (1, Fig. 14) fully into heat exchanger (2) against stop.
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 8.5.2).
3. Withdraw combustion chamber (1, Fig. 14) from heat exchanger (2) and remove.
4. Perform procedures on components after disassembly (refer to 9.1.1).

9.2.11.2 Installation

1. Slide combustion chamber (1, Fig. 14) fully into heat exchanger (2) against stop.
2. Swing burner closed (refer to 8.5.2).

NOTE

Observe electrical wiring color coding when making connections.

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

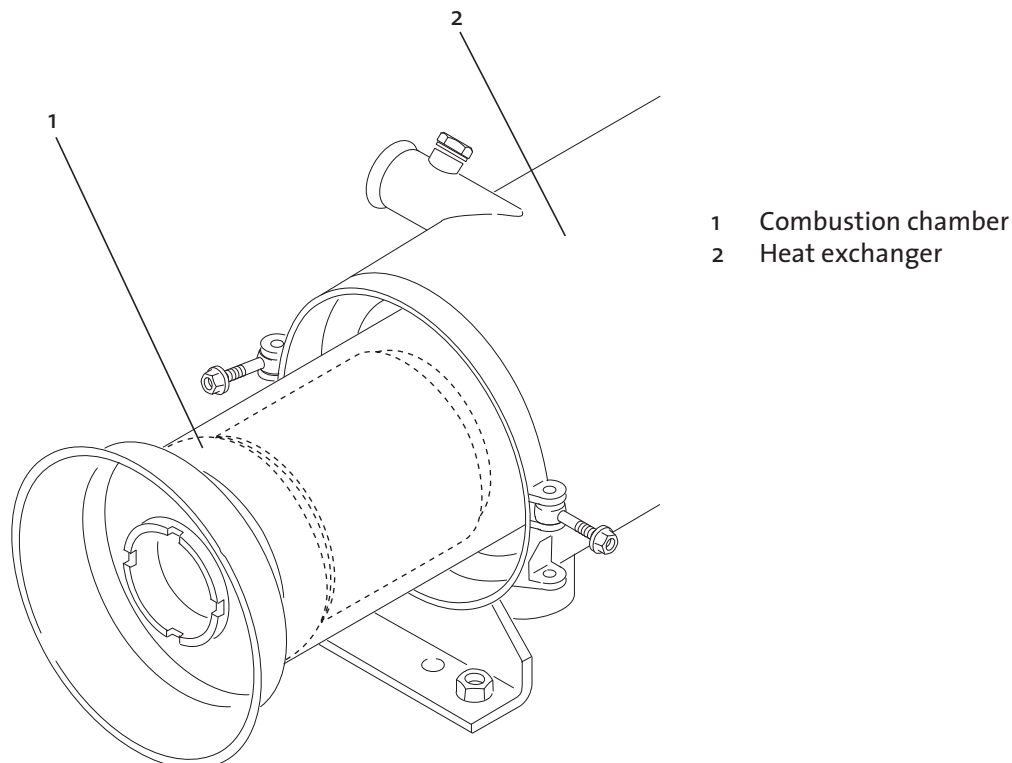


Figure 14: Heat Exchanger and Combustion Chamber, Replacement

Heater, Scheduled Maintenance

The heater should be checked in regular intervals at least at the beginning of the heating season (point of

time when weather conditions cause increased use of heater).

The maintenance intervals indicated below apply to applications and requirements typical of buses.l

Check / Maintenance	Important Notes	Check Result		Measured Values, Maintenance / Repair performed
		o.k.	not o.k.	
1. Electrical connections a) Disconnect electrical connectors to cable harness, inspect for oxidation, spray and reconnect after performing step 5. b) Inspect fuses for oxidation and/or check transition resistances.	Use suitable contact spray, e.g. special contact spray (order no. 101322).	<input type="checkbox"/>	<input type="checkbox"/>	
2. Heat exchanger a) Inspect paint for dark stains of burn (local overheating). b) Check for signs of leakage. c) Clean heater exterior and interior.	If necessary investigate reason for overheating (e.g. water circuit). Check temperature limiter.	<input type="checkbox"/>	<input type="checkbox"/>	
3. Fuel system a) Check fuel lines and connections for leaks. b) Replace fuel filter cartridge with gasket. c) If existing, open fuel shut-off cocks. d) Fuel pump and fuel lines. e) Replace fuel filter screen with gaskets in pump.	Check for tight connections in fuel supply and return! Retighten joints and hose clamps. Replace pump and lines every 5 years.	<input type="checkbox"/>	<input type="checkbox"/>	
4. Burner head a) Check combustion air inlet for contamination. Swing burner head open: b) Check cover for damage c) Check housing interior for accumulation of fuel caused by leaks. d) Clean viewing glass of flame sensor. e) Check igniter electrodes for condition. f) Replace nozzle.	Replace damaged cover Replace bent electrodes. When coked reduce replacement interval for fuel filter.	<input type="checkbox"/>	<input type="checkbox"/>	
5. Exhaust system a) Check exhaust line for contamination and clean as required. b) Remove combustion chamber from heat exchanger, inspect both components for damage and contamination and clean or replace as required. c) Insert combustion chamber and mount burner head. Check for secure connection to heat exchanger. d) Restore electrical connections.		<input type="checkbox"/>	<input type="checkbox"/>	
6. Water system a) If installed, clean water filter. b) If installed, open water shut-off cocks.		<input type="checkbox"/>	<input type="checkbox"/>	
7. Functional checks a) If installed, open shut-off cock in return line. b) Check heater function. c) Check for smoke emissions in run-down; replace nozzle if required.	after at least 10 min. of heating operation.	<input type="checkbox"/>	<input type="checkbox"/>	

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Subject to modification

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