

HEATING SYSTEMS

THERMO AC 070

THERMO AC 200

THERMO DC 200

THERMO DC 070-140-200

Workshop Manual

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1 Introduction

1.1 Content and purpose

This workshop manual is used during maintenance and repair of water heaters (further referred to as heaters) Thermo AC070, 200 und Thermo DC200.

 Warning!	Danger to life and health!
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Electrical work may only be performed by persons, which have the required qualification (see 1.6.1).

ATTENTION:

Work on the heater may only be performed by briefed and/or trained by Spheros personnel. Any changes to the heaters are strictly prohibited and will void both the warranty and, if applicable, the E1 approval.

1.2 Effectivity of the workshop manual

The workshop manual applies to heaters listed on the title page of this document. It may be subjected to modifications and amendments. The respectively currently effectife version is binding. This version can be found in the download center under www.spheros.com.

1.3 Meaning of highlighted content

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

 Warning!	Danger to life and health!
---	-----------------------------------

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

 Caution!	Hazardous to health!
---	-----------------------------

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

ATTENTION:

This caption points to actions which may cause material damage.

NOTE:

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

1.4 Symbols



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

1.5 Further documentation to be used

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

- Installation and operating instructions Thermo AC/DC
- Spare parts list Thermo AC/DC
- Technical Information (TI)

This service literature is also available for download in the download center under www.spheros.com.

1.6 Safety information and regulations

Basically, general accident pevention provisions and the valid industrial safety directions must be adhered to. "General Safety Regulations" which exceed the framework of these provisions are listed below.

The specific safety regulations which affect the present manual are issued highlighted in the individual sections or procedures.

1.6.1 Required qualifications

 Warning!	High voltage! Danger to life!
---	--

Electrical work may only be performed by a qualified electrician for HV systems in motor vehicles, craftsman, activity with repetitive character. Training acc. to DGUV 200-005 (previously BGI 8686), at least level 2.

NOTE:

The provisions of these Regulations are binding within the territory governed by DGUV Regulations and should similarly be observed in countries without specific regulations.

Country specific rules / standards are to be considered additionally.



Even before the start of non-electrical work, the voltage-freeness must be determined by a skilled electrician.

1.6.2 Emergency stop / de-energizing

The Thermo AC/DC heaters itself do not have an emergency stop system. Their control and power supply is integrated into the vehicle's electrical system.

It is therefore the responsibility of the user to inform himself before the commissioning of the heater in the vehicle how the heater can be successfully de-energized if necessary (maintenance, service work, abnormal behavior etc.).

1.6.3 Work at the heater



Installation, maintenance and repairs may only be carried out when the vehicle's engine is not running and the high voltage supply (AC/DC) / power supply is switched off.

Before starting the work at the heater, it is to make voltageless acc. to DIN VDE 0105-100 and this state must be ensured for the duration of the work.

The following safety precautions must be observed:

- switch off the power supply to the heater
- ensure it cannot be switched on again
- verify system is voltage-free, all poles
- ground and short circuit (the de-energized circuit)
- cover or block neighbouring parts under voltage

Electrical cables and operating elements of the heater must be arranged in the vehicle in such a way that their functioning is faultless under normal operating conditions and cannot be hampered.

Work at electrical equipment may only be started if protective measures against electric shock, short circuits and arcing faults have been carried out.



Familiarize yourself with the Thermo AC/DC Installation instructions before you make any modifications to the existing heater installation.

NOTE:

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

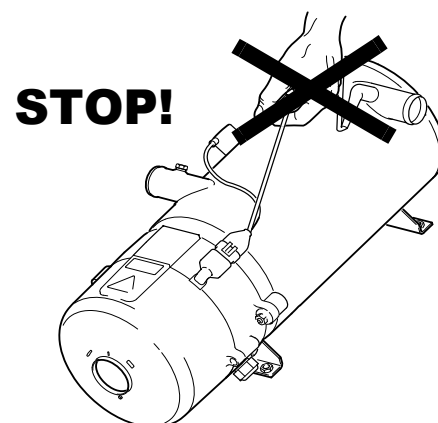
Further they contain safety instructions and regulations to be followed for safe operation of the heater.

1.6.4 Other safety information

1.6.4.1 Temperature sensors

ATTENTION:

The cables of the temperature sensors (temperature limiter, control thermostat) may not be mechanically stressed (pull on the cable, carry the heater at the cable etc.).



1.6.4.2 Cleaning

ATTENTION:

Cleaning with liquid media is to be avoided, as the insulation resistance can be reduced by water ingress.

1.7 Suggestions for improvement and change

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

service@spheros.com

2 Technical data

Except where limit values are specified, these technical data refer to the usual heater tolerances of $\pm 10\%$ at an ambient temperature of $+20^{\circ}\text{C}$ and at the rated voltage.

Table 201 Technical data

Heater	Thermo AC070	Thermo AC200			Thermo DC 070/ DC 140/ DC 200	Thermo DC200		
Heater Ident.-No.	11117427	11140183	11125621	11116255	11141607	11117083	11122596 and others *	11126153
Kind of design	electrical operated heater							
Ambient temperature during operation	$^{\circ}\text{C}$	-40...+ 85	-40...+ 60	-40...+ 85				
Storage temperature	$^{\circ}\text{C}$	-40...+ 90						
Operating overpressure	bar	max. 2.0						
Capacity of the heat exchanger	l	9.9	9.4					
Minimum water flow	l/h	>1500						
Minimum capacity of the water system	l	25						
Antifreeze ratio in the cooling system	%	30 - 60						
Device dimensions (tolerance ± 3 mm)	mm	length: 578 / wide: 247 / height: 225						
Weight	kg	12.5	15					

* 11122677, 11125620, 11139411, 11125503, 11140458,
11144705, 11146105, 11146242, 11148103, 11147978, 11148246

Heater (electrical system) continued		Thermo AC070	Thermo AC200			Thermo DC 070/ DC 140/ DC 200	Thermo DC200		
Heater Ident.-No.		11117427	11140183	11125621	11116255	11141607	11117083	11122596 and others *	11126153
Nominal heating flow	kW	6.6	20						
Nominal voltage	VDC	3/PE/N AC 400/230V				690	690	486	
Power consumptio	kW	6.6	20						
Frequency	Hz	50 - 60				--			
Nominal current	A	10	30			9.8/ 19.5/ 29.6	29.6		41.7
Rated current at 540V DC	A	--				7.8/ 15.6/ 23.2	23.2		34.4 @ 400V
Rated current at 690V DC	A	--				9.8/ 19.5/ 29.6	29.6		41.7 @ 486V
Rated current at 750V DC	A	--				10.7/ 21.5/ 32.2	32.2		46.4 @ 540V
Rated current at 900V DC	A	--				12.9/ 25.7/ 38.6	--	38.6	51.5 @ 600V
Type of electrical protection		Circuit breaker all pole 16A	Circuit breaker all pole 32A			1000V DC/xxA/10kA fast-blow			
Circuit breaker rating	A	16	32			50*	35	50*	60*
Operating voltage range HV	VAC	- 400	175 - 400	- 400	175 - 400				
	VDC	--				0 - 900	450 - 750	0 - 900	0 - 600
Cross section HV supply cable	mm ²	--	6	6	--	6	4	6	10
HV wiring harness at heater side		--	5 ea wire ferrules 6mm ²		--	2 ea wire ferrules 6mm ²	2 ea wire ferrules 4mm ²	Hook-up see heater DWG	2 ea wire ferrules 10mm ²
Min. cable cross section at vehicle side	mm ²	5x4				6	4	6	10

* 11122677, 11125620, 11139411, 11125503, 11140458,
11144705, 11146105, 11146242, 11148103, 11147978, 11148246

Continued on next page

Heater (electrical system) continued		Thermo AC070	Thermo AC200			Thermo DC 070/ DC 140/ DC 200	Thermo DC200		
Heater Ident.-No.		11117427	11140183	11125621	11116255	11141607	11117083	11122596 and others *	11126153
Total resistance of all HV heating cartridges	Ω	L-N: 23.3 L-L: 46.6	L-N: 7.8 L-L: 15.5			46.6/ 69.9	23.3	23.3	11.65
Insulation resistance new device at 1000V	M Ω	>100							
Insulation resistance end of life at 1000V	M Ω	>50							
Control signal nominal voltage	VDC	24	--	24	--	24	--	24	
Operating voltage range LV	VDC	19.2 - 26.4	--	19.2 - 26.4	--	16 - 32	--	16 - 32	
Max. control current LV	A	0.55				1.58	0.42	1.58	
LV circuit breaker current rating	A	5							
LV control harness connector		FEP 42064500	AMP HDSC 8 pin 1-1418479-1	FEP 42064500	AMP HDSC 16 pin 1-1564337-1	FEP 42064500	AMP HDSC 8 pin 1- 1418479-1		
Mating plug		FEP 42121100	AMP HDSC 8 pin 1-1564416-1 or 1-1564512-1	FEP 42121100	AMP HDSC 16 pin 1-1564528-1 or 1-1564407-1	FEP 42121100	AMP HDSC 8 pin 1- 1564416-1 o. 1- 1564512-1		

* 11122677, 11125620, 11139411, 11125503, 11140458,
11144705, 11146105, 11146242, 11148103, 11147978, 11148246

*** NOTE:**

The circuit breaker rating is based on the maximum operating voltage of 900V DC. The rating must be adapted to the highest operating current and the temperature derating of the circuit breaker.

The minimum cable cross-sections specified in the table must be observed.

Cable length <7.5m	Cable length 7.5 - 15m
0.75 mm ²	1.5 mm ² *
2.5 mm ²	4.0 mm ² *

* Cable cross-section must be reduced again to 0.75 or 2.5mm² in front of the heater.

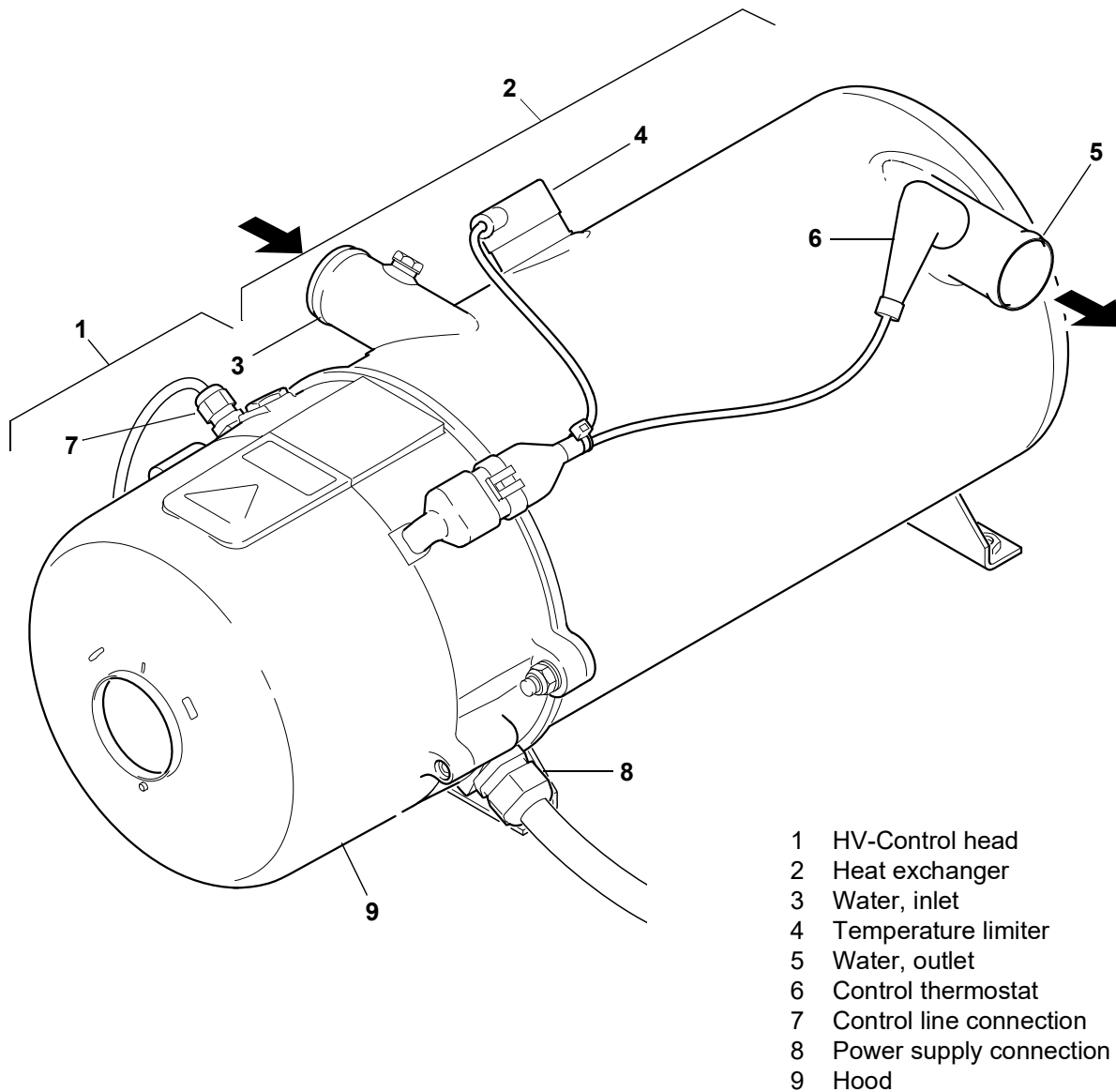
3 Description of assemblies and components

The fully electrical water heaters Thermo AC/DC operate independently of the vehicle engine and are connected to the vehicle's cooling and electrical systems. Thus, they can be used in a depot for pre-heating purposes. For this the AC heater is connected stably to the depot mains 3/PE/N AC 400/230V 50Hz. Further more the heaters also can be used in electric driven buses or hybrid buses

where a 600 (690) VDC (DC heaters) or a 3/PE/N AC 400/230V 50Hz (AC heaters) power supply is provided in association with the vehicle's own heating system:

- to heat the passenger cabin, and
- for pre-heating.

The heaters are approved for horizontal installation only.



- 1 HV-Control head
- 2 Heat exchanger
- 3 Water, inlet
- 4 Temperature limiter
- 5 Water, outlet
- 6 Control thermostat
- 7 Control line connection
- 8 Power supply connection
- 9 Hood

Fig. 301 Heater overview

The heater is bolted down to the vehicle chassis or is secured using an additional cross beam.

The heat is generated by the heating of heating cartridges by means of electrical energy. The heating cartridges are part of the heat exchanger and are therefore integrated directly into the coolant circuit. As a result, the generated heat can pass into the cooling circuit without loss.

The adaptation to the changing demand of heat is reached by intermittent operation (intermittent mode). In principle the heaters of the Thermo AC/DC series consist of the main components:

- HV Control head
- Small distribution board
- Heat exchanger
- 3, 6 or 9 heating cartridges
- Temperature sensors

3.1 HV Control head

The HV control head consists of an aluminum die-cast ring and the hood. Inside is the small distribution board. The heat exchanger is screwed to the rear of the control head.

3.2 Small distribution board

The small distribution board consists of a 35mm standard rail on which the electrical components required for the heater are mounted (see [Fig.302](#) and [Fig. 303](#)).

The standard rail is attached to the heat exchanger by means of stay bolts.

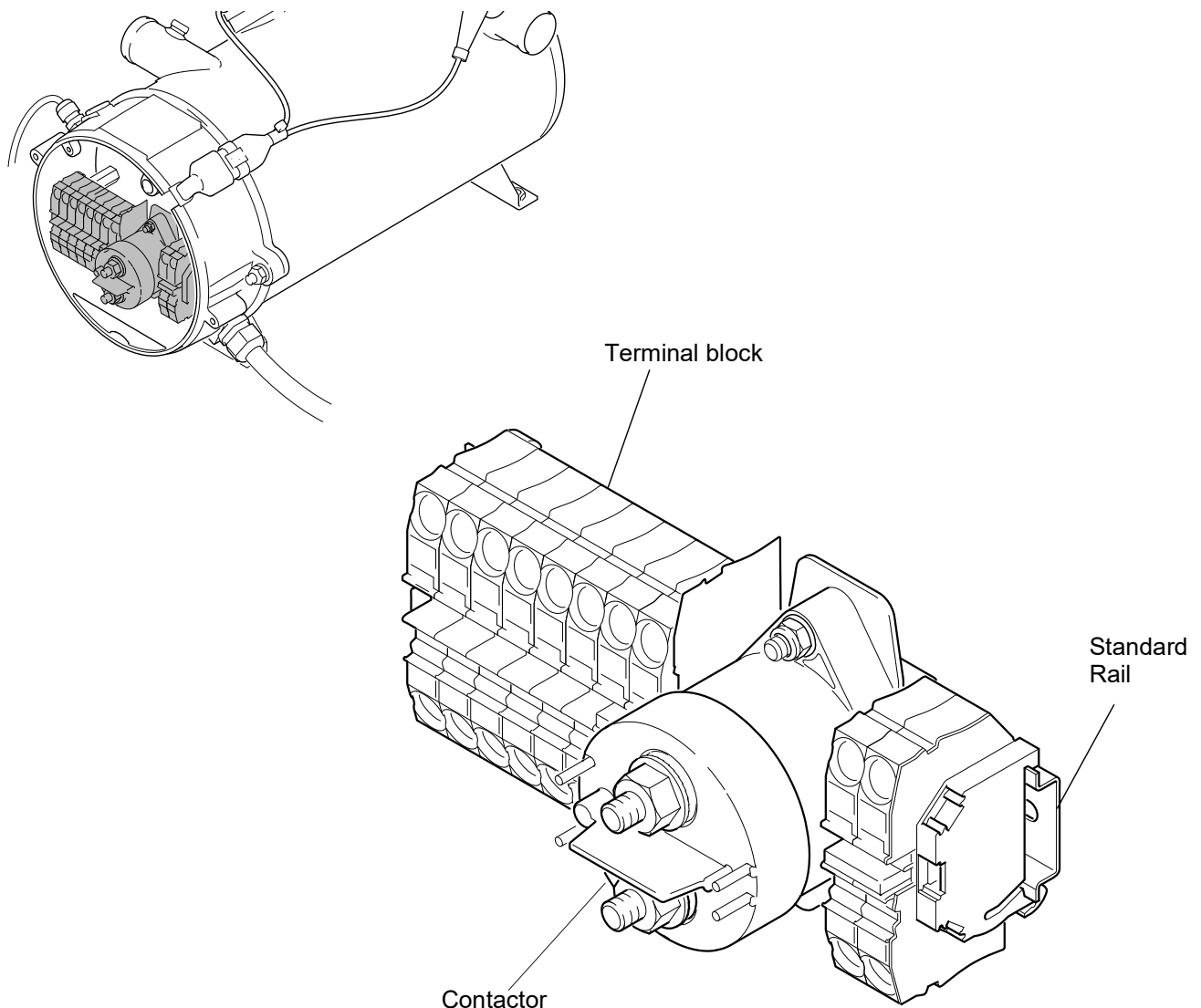


Fig.302 Example of a small distribution board of AC heaters (version with power supply unit)

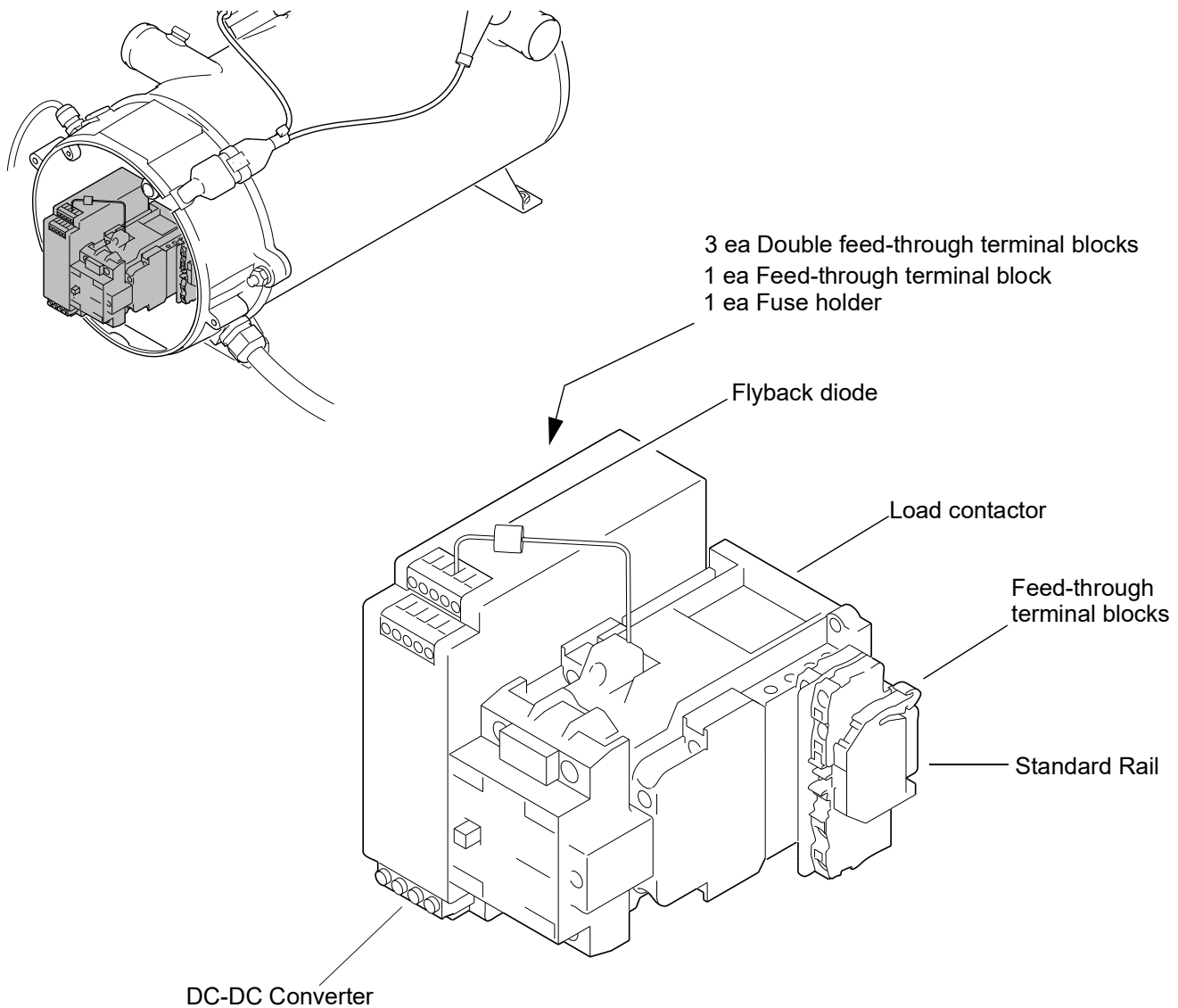


Fig. 303 Example of a small distribution board of DC heaters

3.3 Heat exchanger

In the heat exchanger (1, Fig. 304) the water flowing through is heated by heating cartridges (6) arranged in it. The cylindrically welded construction has a water inlet (2) and a water outlet (3). The heater is integrated into the cooling water circuit via these two connection ports. In the water outlet (3) the control thermostat (4) is screwed in. In the wall of the heat exchanger the temperature limiter (5) is installed. The plate at the front has receiving openings with threads for the heating cartridges (6).

3.4 Heating cartridges

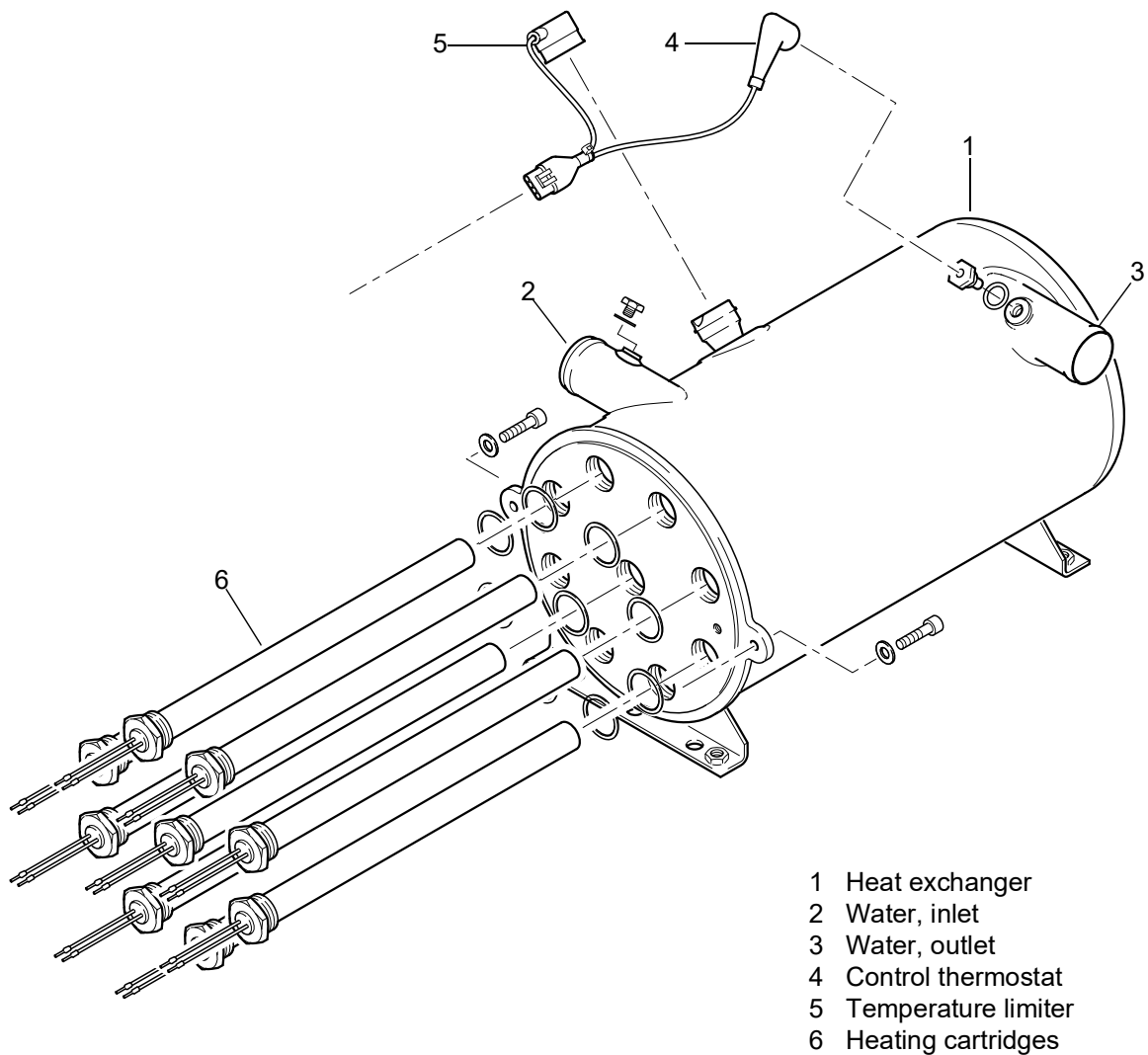
At the end of the rod-shaped, water-proof heating cartridges (6, Fig. 304) there is an external thread with a hexagon for screwing in and the electrical cables are led out.

ATTENTION:

The heating cartridges must always be screwed in with a new gasket!

3.5 Control thermostat

The control thermostat (4, Fig. 304) captures the coolant temperature at the heat exchanger outlet.



- 1 Heat exchanger
- 2 Water, inlet
- 3 Water, outlet
- 4 Control thermostat
- 5 Temperature limiter
- 6 Heating cartridges

Fig. 304 Heat exchanger with installed on/in it components (exploded)

The signal is transmitted to the load contactor, where it is processed.

The shutdown is carried out at 75 ± 3 °C, the restart is carried out at 68 ± 5 °C.

3.6 Temperature limiter

The temperature limiter (5, Fig. 304) protects the heater from unacceptably high temperatures. The temperature limiter switches off the heater at a temperature greater than 125 °C .

The temperature limiter is mechanically resettable at a temperature <90 °C.

4 Functions of the heater

4.1 General functional description of the heater

In the fully electrical operated heater Thermo AC/DC the coolant of the vehicle is heated by electric heating cartridges.

Control elements to switch the heater on and off can be:

- Switches
- Relays
- Spheros preselection timer

To monitor the operation an operation indicator or the Spheros preselection timer is to be provided.

The heating cartridges are switched by a load contactor. The control voltage for the contactor is generated by an AC/DC converter (integrated in the Thermo AC200/DC200 in the heater).

On the vehicle side, the control circuit contains an operating element by means of which the heater is taken into

operation. On the heater side, a control thermostat and a temperature limiter are integrated, which are attached to the heater. In operation, they enable the heating cartridges to be switched on automatically when a lower switching threshold is reached and their switching off when the upper switching threshold is reached (regulating thermostat) as well as a switching off of the heater in the event of an overheating (temperature limiter). [Table 401](#) shows the corresponding default values.

The heater must be protected and monitored on the vehicle side by a ground fault interrupter (AC) respective an insulation monitoring device.

Heating is only permitted with a sufficient coolant flow rate (> 1500 l / h).

When the heater is switched off, ensure that the circulating pump is still running 120sec.

Table 401 Standard switching thresholds

	Standard
Lower switching threshold in °C	68
Upper switching threshold in °C	75
Overheating protection in °C	125

4.2 Functional sequence of the heater

4.2.1 Switching on

In order to switch on the heater, 24V DC respectively the switch on signal must be connected according to the valid wiring diagram to the AC/DC control wiring harness for external control by an operating or control element (for example, switch, relay, pre-selection timer) installed on the vehicle.

This power is fed to the load contactor, the control thermostat and the overheat protection (see chapter 3), which constitute the control loop of the AC/DC control head.

The temperature guards interrupt the current path for activating the contactor when their switching thresholds are reached.

If all of the following three conditions are met:

1. 24V DC is applied to the external control input or the switching contact is closed,
2. The control thermostat has not yet reached the upper switching threshold / has fallen below the lower switching threshold,
3. The overheating protection has not yet reached the upper switching threshold,

the contactor is activated, the moving core attracts and closes the main contacts.

In this way the heating cartridges connected to the contactor are powered. Each heating cartridge now converts the electrical energy into heat.

4.2.2 Heating operation

The control thermostat opens its contact at 75°C and closes it again at 68°C.

In this way, the heating operation is regulated.

The overheat protection opens its contact at 125°C and must be mechanically reset by service personnel.

ATTENTION:

After the overheating protection has been triggered, the cause of the overheating must first be removed before it is reset.

4.2.3 Switching off

When the 24V DC control voltage / switch on signal at the external control terminal is interrupted by a vehicle installed control element (e.g. switch, relay, pre-selection timer), the load contactor opens and the voltage supply of the heating cartridges is switched off.

The circulating pump in the coolant circuit must continue its operation at least 120s.

4.3 Malfunctions caused by overheating / tripping of the temperature limiter

If the heater is overheated, the temperature limiter is tripped and the heater goes into a fault lock-out.

The circulating pump in the coolant circuit must continue its operation at least 120s.

After cooling down and remedy the cause as well as the inspection of the heater for possible damage, in particular the wiring, the temperature limiter and the control thermostat, the button of the temperature limiter must be reset manually.

NOTE:

The Chapter 5 contains approaches for troubleshooting.

5 Troubleshooting and error correction

5.1 General



Warning!

Danger to life and health!

The safety information and regulations of Chapter 1 (see 1.6) must be observed.

This section describes troubleshooting and error correction for Thermo AC/DC heaters.

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

Error detection is usually limited to localizing the faulty component.

The following malfunction causes are not taken into account and should basically always be verified and/or a malfunction due to these reasons should be excluded:

- Corrosion on plugs
- Loose plug connections

- Crimp failures on plugs and/or pins
- Corrosion on cable and fuses
- Cable insulation damage

ATTENTION:

Prior to replacing a fuse, troubleshooting needs to be performed. The heater must be disconnected from the vehicle electrical system.

A properly dimensioned fuse must be inserted (see chapter 6 wiring diagrams).

After each error correction a functional test must be performed in the vehicle.

5.2 General error symptoms

The following table lists possible, general error symptoms.

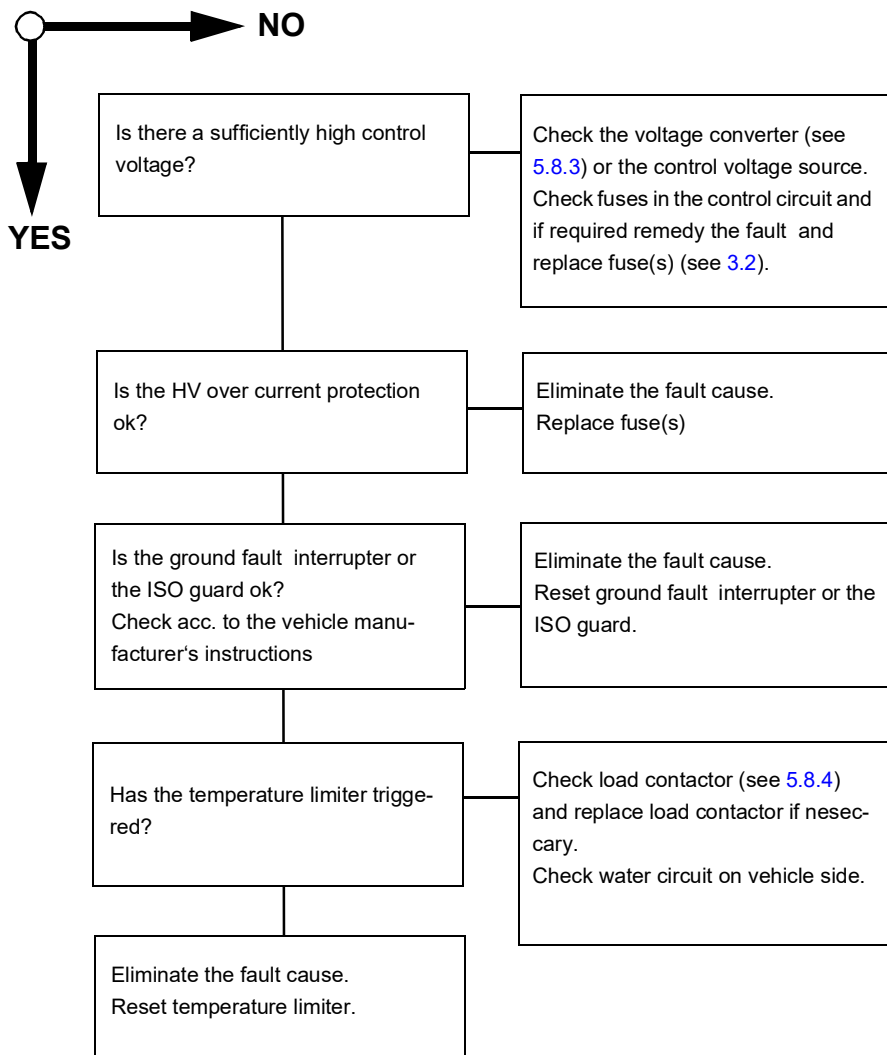
Table 501: General error symptoms

Error symptom	Possible cause
<p>Heater can not be switched on.</p> <p>Operation indicator does not light and the heater does not function.</p> <p>Heater is functional, however the operation indicator does not light.</p>	<ul style="list-style-type: none"> • Missing or insufficient supply voltage (24V) • 24V fuses defective or not active • Supply lead to the plug contacts of the HV control wiring harness (24V) defective or contact not established • Plug of the temperature sensors not connected • Temperature sensors defective • HV small distribution board defective • HVIL (Interloop) – failure (if existent) • No supply voltage • Fuses • Operation indicator defective or cables to the operation indicator interrupted or shorted.
<p>ISO guard triggers because the ISO value is too low.</p>	<ul style="list-style-type: none"> • Insulation of one or more cables is damaged and in contact with the electrically conductive structure of the heater or vehicle • Heater/heating cartridges is/are overheated
<p>Temperature in the water circuit is too high/low</p>	<ul style="list-style-type: none"> • Control thermostat defective • Diodes in LV wiring harness defective (if applicable, heater may be hooked-up incorrectly).

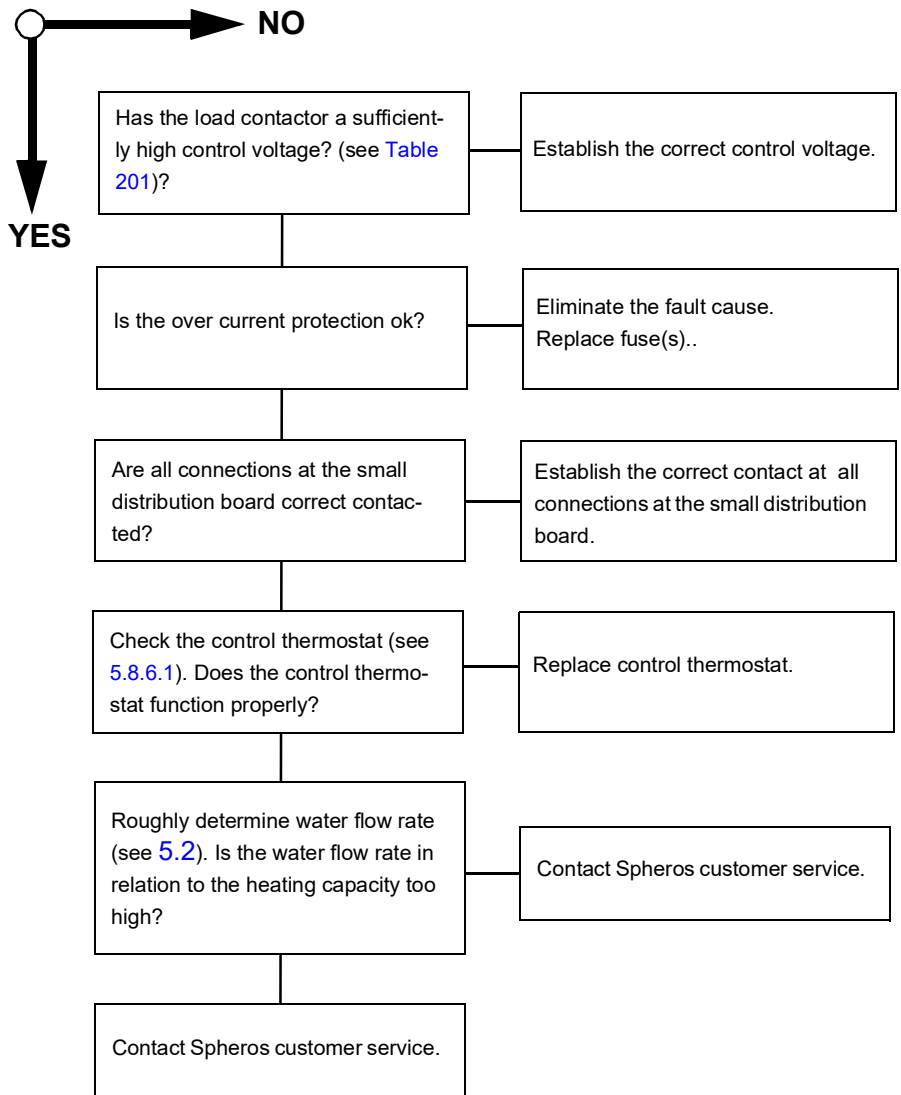
Table 501: General error symptoms

Error symptom	Possible cause
Heater can not be switched off.	<ul style="list-style-type: none"> Supply voltage (24V) not switched off HV small distribution board defective Diodes in LV wiring harness defective (if applicable, heater may be hooked-up incorrectly).
Heater does not heat.	<ul style="list-style-type: none"> No HV supply connected / active HV fuses defective or not active Ground fault interrupter or insulation monitoring device (IMD) defective or not active HV small distribution board defective Heating cartridge(s) defective
No HVIL (Interloop) signal (if existent)	<ul style="list-style-type: none"> SC600 respective the control unit does not transmit a HVIL signal HVIL contact is not established Hood not (correctly) mounted HV cable not connected HV control wiring harness (24V) not connected or cable defective
Heating power too low	<ul style="list-style-type: none"> HV supply power too low Heating cartridge(s) defective
Heating power too high	<ul style="list-style-type: none"> HV supply power too high
Overheating, temperature limiter has triggered	<ul style="list-style-type: none"> Control thermostat defective
Heater stops as the connected heat exchangers provide insufficient heat.	<p><u>Flow rate too small, because</u></p> <ul style="list-style-type: none"> Air in the heater, heat exchanger or in system sections. Taps/valves (flow controllers) throttled, contaminated, closed. Contaminations in the system, e.g. filters or at bottlenecks. Circulating pump delivery rate insufficient (air in pump housing). Insufficient frost protection. System resistance too high (especially high in the cold). Circulating pump defective. <p><u>Heat exchanger provides not enough heat, because</u></p> <ul style="list-style-type: none"> Air in the heat exchangers and/or system sections. Antifreeze content too high. <p>Approximate flow rate determination:</p> $\text{Flow rate in [l/h]} = \frac{\text{Heat flow [kW] according to type plate}}{\text{Temperature difference } \Delta t \text{ in [K] or [°C] measured on the heater between water inlet and water outlet (e.g. using contact thermometer)}} \times 860$

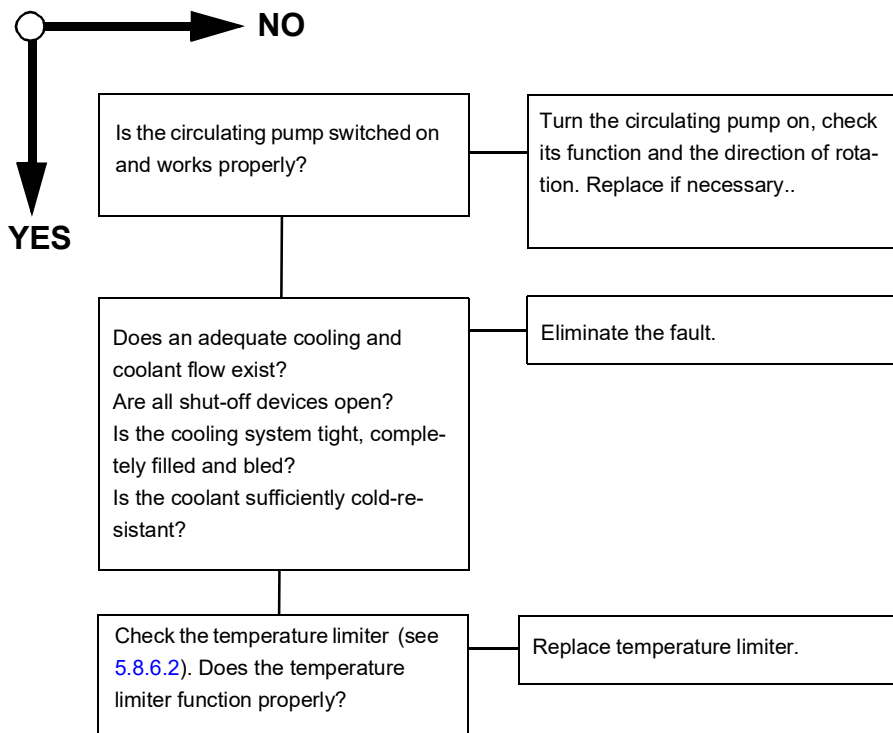
5.3 Error symptom “Total failure of the heater“



5.4 Error symptom “Heating power too low or permanent operation“

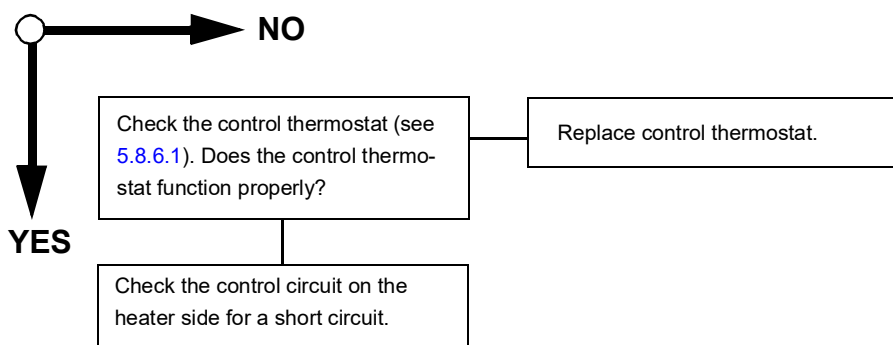


5.5 Error symptom „Overheating / the temperature limiter has tripped“



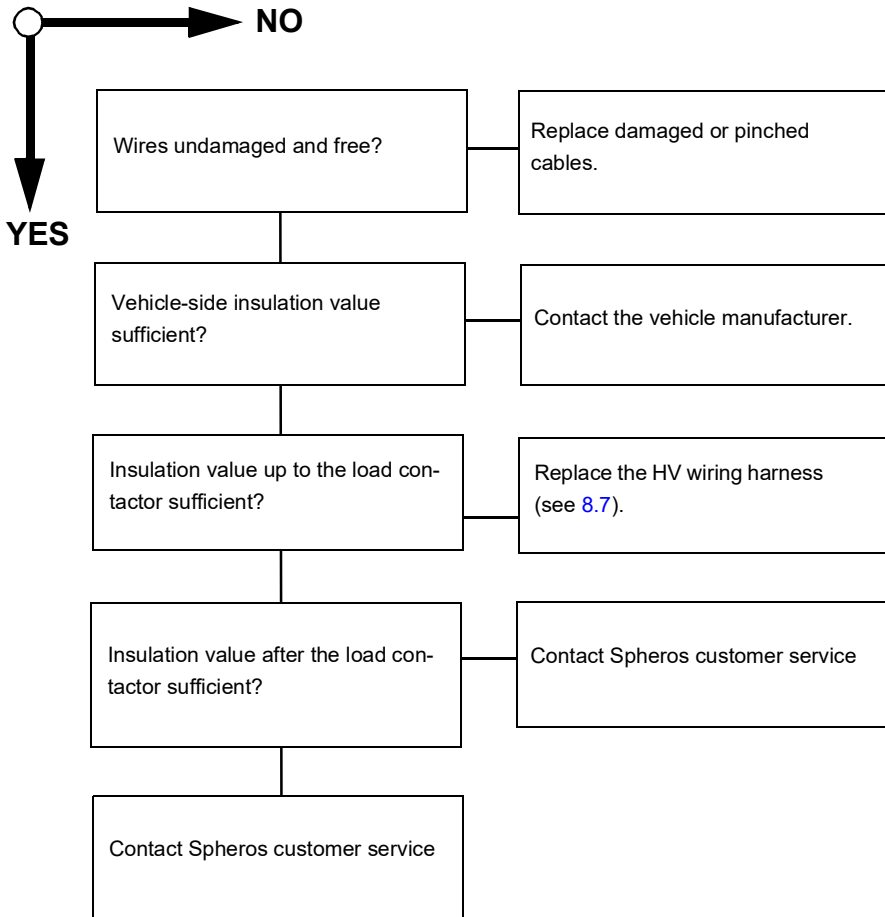
5.6 Error symptom „Over heating“

The upper switching threshold is exceeded, but the temperature limiter does not trip.



5.7 Error symptom “ISO value too low (unacceptable)”

Perform a visual inspection whether cables are damaged or squashed and rest against the housing (metal parts). The insulation resistance must be measured at a test voltage of 1000V DC.



5.8 Individual component tests

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

5.8.1 General visual inspection

- Inspect components for damages (cracks, deformation, leaks, discolourations, etc.) and replace as needed.
- Inspect plugs and cables for corrosion, contact and crimp errors and repair as needed.
- Check plug contacts for corrosion and tight fit. Repair as needed.
- Inspect warning placards / replace if absent or illegible
- Check that all cables and lines are sufficiently secured with cable ties. In case of insufficient fixation or damaged cable ties, retrofit or replace them.

5.8.2 Heat exchanger visual inspection

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

ATTENTION:

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

5.8.3 Voltage converter check or visual inspection

- Inspect voltage converter for damage (cracks, deformation, discoloration etc.) and if required replace small distribution board.
- Inspect wires for corrosion, contact and crimp errors etc. and replace if required.

5.8.4 Load contactor check or visual inspection

- Inspect load contactor for damage (cracks, deformation, discoloration etc.) and if required replace small distribution board.
- Inspect wires for corrosion, contact and crimp errors etc. and replace if required.

5.8.5 Heating cartridges check or visual inspection

- Inspect heating cartridge (from outside) for damage (cracks, deformation, discoloration etc.) and replace if required.
- Inspect wires for corrosion, contact and crimp errors etc., replace heating cartridge if required.

5.8.6 Check of the temperature guards (control thermostat and temperature limiter)

5.8.6.1 Control thermostat check

NOTE:

The control thermostat must be screwed in tight (by hand) and the protective cap must be installed. The cable must not be damaged.

Check

During the test with a digital multimeter CAT III, the control thermostat is to be tested for continuity.

The control thermostat is connected to pins 3 and 4 of the temperature sensor connector (see [Fig. 501](#)).

Switching temperature:

- opens at $75 \pm 3^\circ\text{C}$
- closes at $68 \pm 5^\circ\text{C}$

At room temperature the contact is closed. When it heats to above the upper switching point, it is opened.

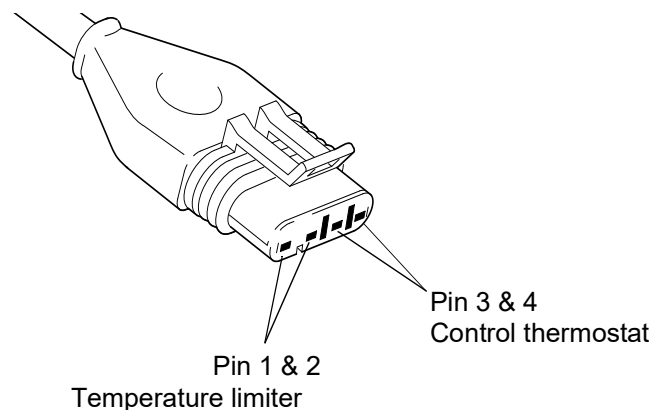


Fig. 501 Temperature sensor connector

5.8.6.2 Temperature limiter check

ATTENTION:

The retaining spring must be in the temperature limiter's slot and must be locked in place on both sides of the housing. The cables must not be damaged and must not be located above the release button.

Check

During the test with a digital multimeter CAT III, the temperature limiter is to be tested for continuity. The temperature limiter is connected to pins 1 and 2 of the temperature sensor connector (see [Fig. 501](#)).

Switching temperature:

- opens at 125°C +8 /-4°C

When it cools down, the temperature limiter remains open until approx. 5°C. Once it reaches a temperature below 90°C, it can be reset by pressing the button.

6 Wiring diagrams

6.1 General

The following figures show wiring diagrams/connecting schematics applicable for the Thermo AC/DC heaters.



Electrical work at the heater may only be performed by persons, which have the required qualification (see 1.6.1).

NOTE:

Consider also the information on the electrical installation given in the Installation and operating instruction. The document is available for download in the download center under www.spheros.com.

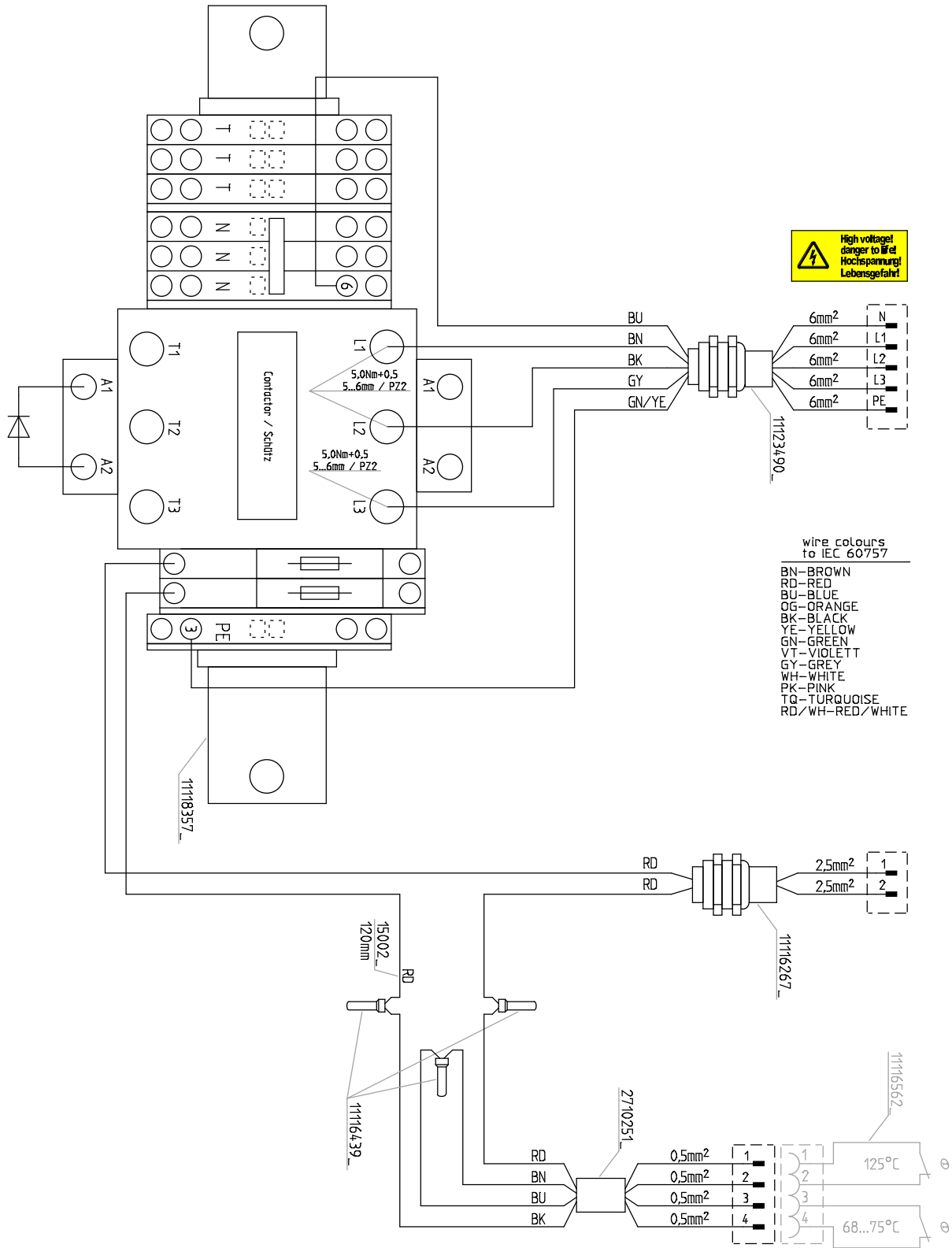


Fig. 601 Housing removal for devices Thermo AC 7 kW without converter
(heater ident. no. acc. to model plate 11117427A)

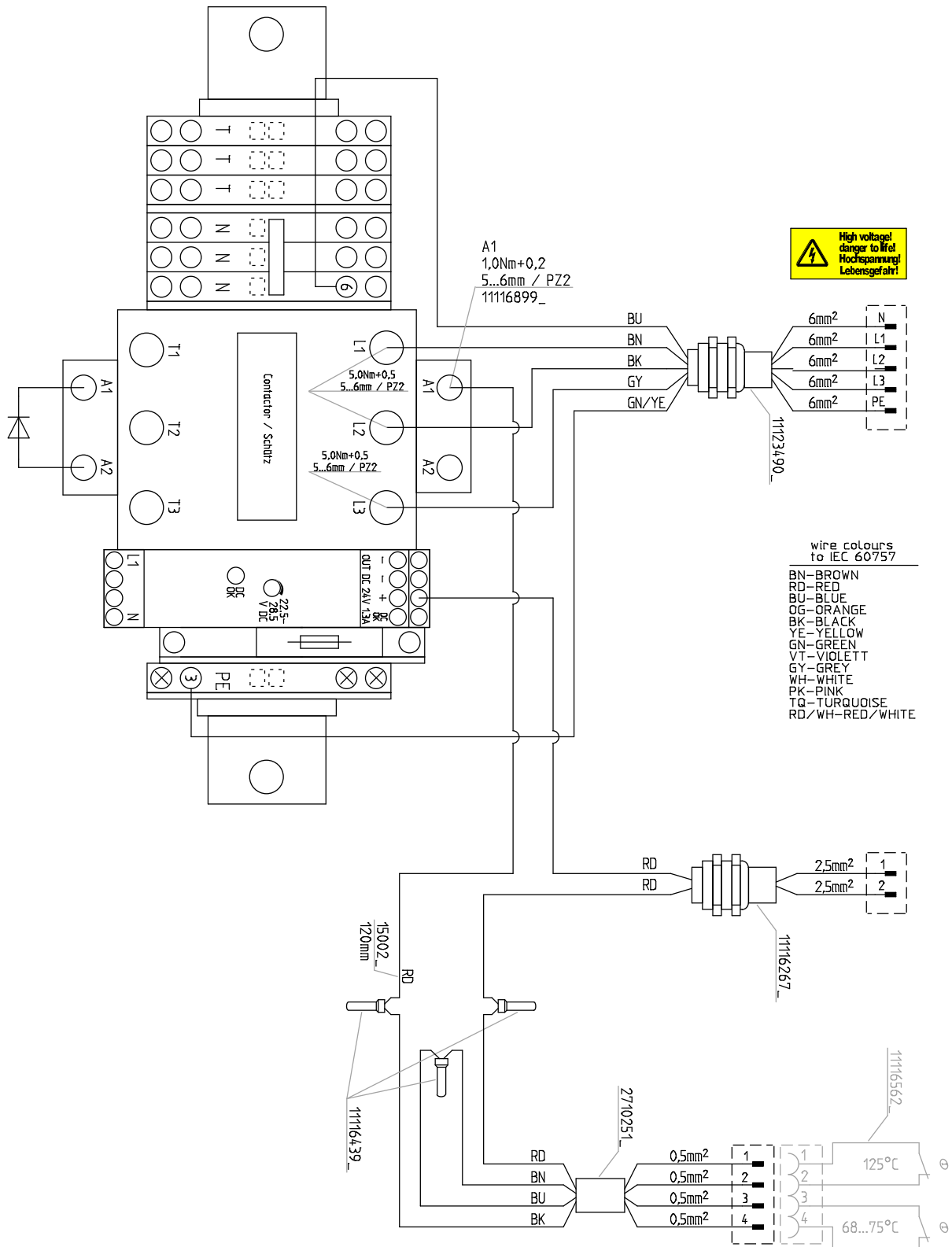


Fig. 602 Housing removal for devices Thermo AC 20 kW with AC-DC converter (heater ident. no. acc. to model plate 11116255A)

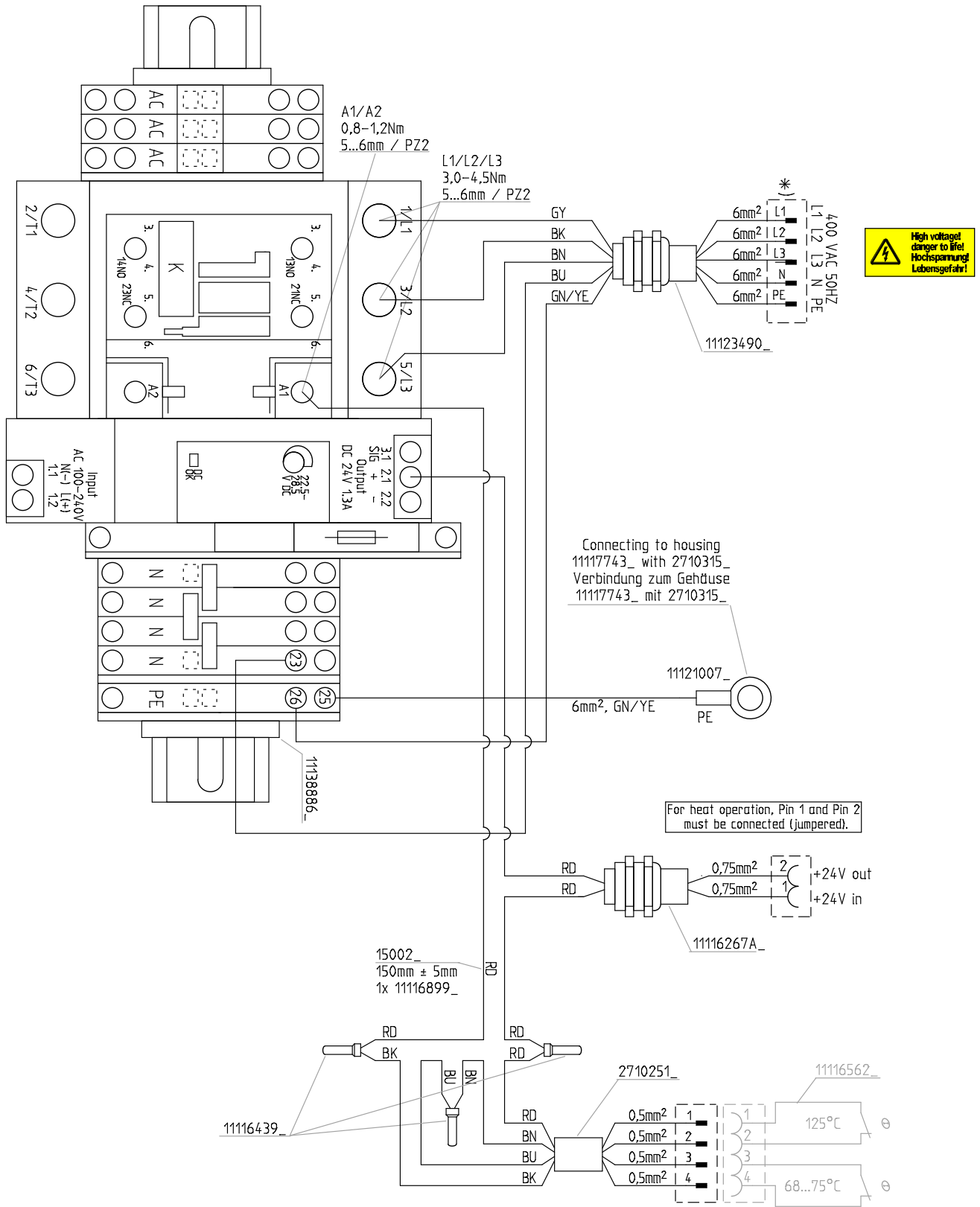


Fig. 603 Housing removal for devices Thermo AC 20 kW with AC-DC converter, with HVIL contact at the hood (heater ident. no. acc. to model plate 11140183A)

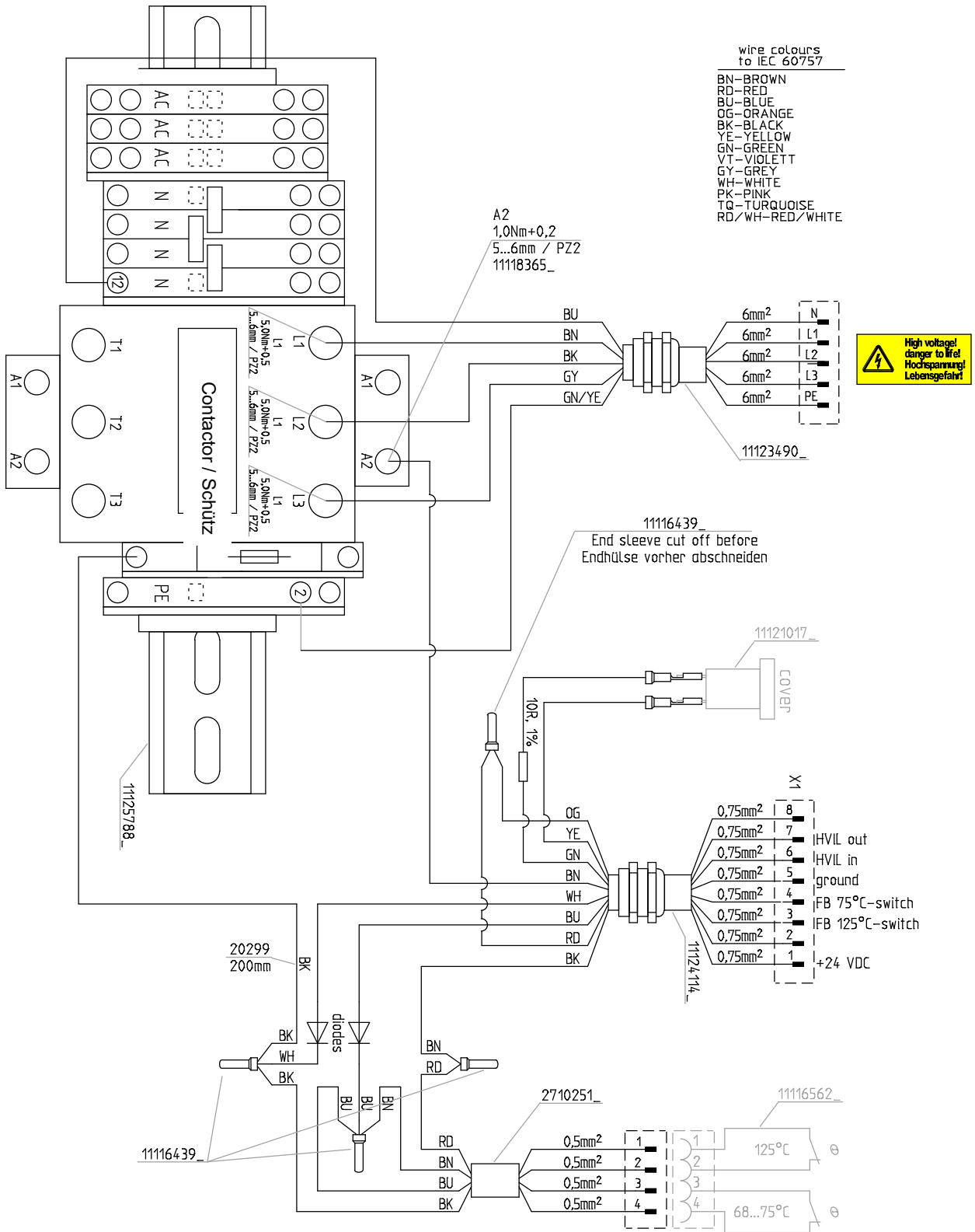


Fig. 604 Housing removal for devices Thermo AC 20 kW without AC-DC converter, with HVIL contact at the hood (heater ident. no. acc. to model plate 11125621A)

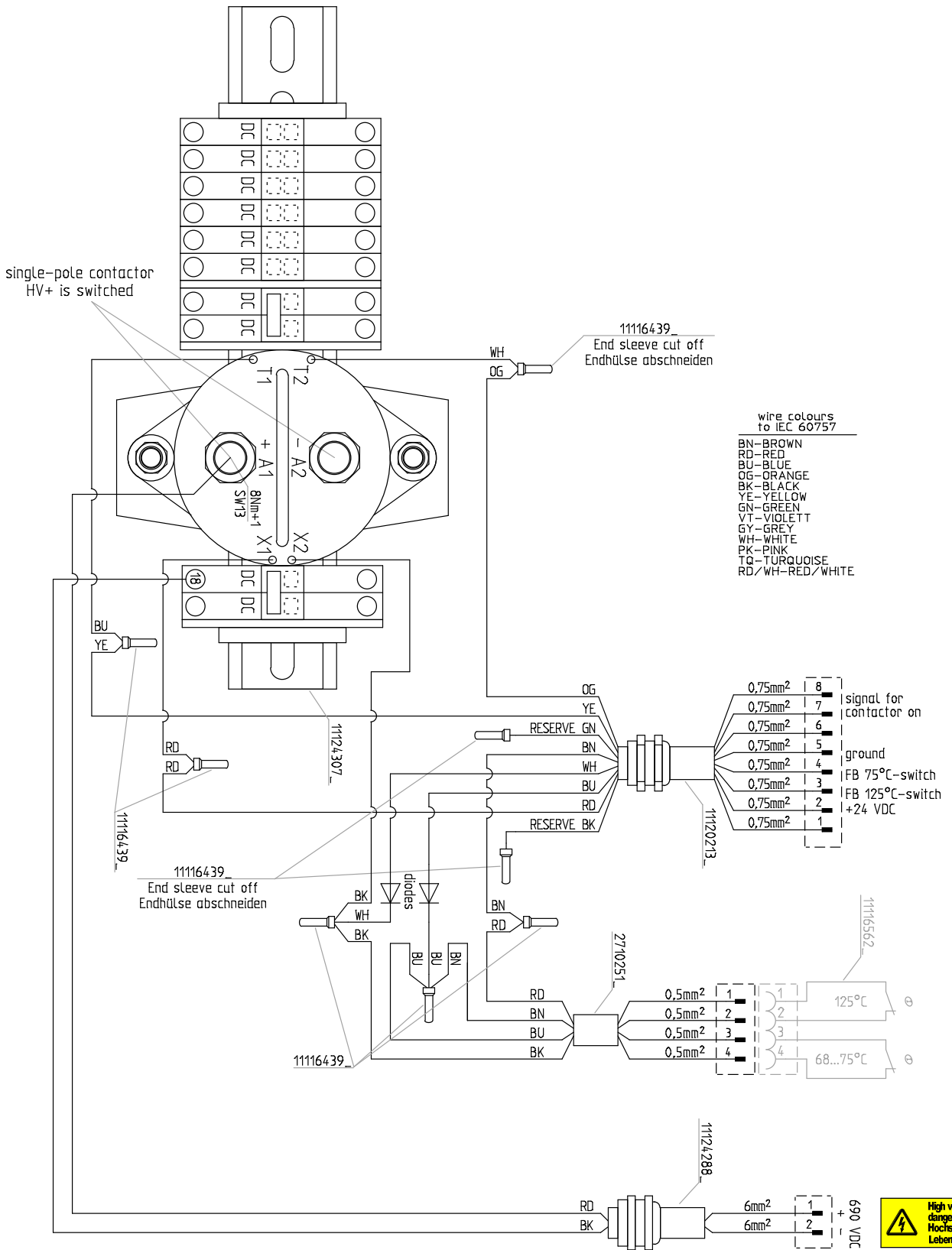


Fig. 605 Housing removal for devices Thermo DC 20 kW without converter (heater ident. no. acc. to model plate 11122596B)

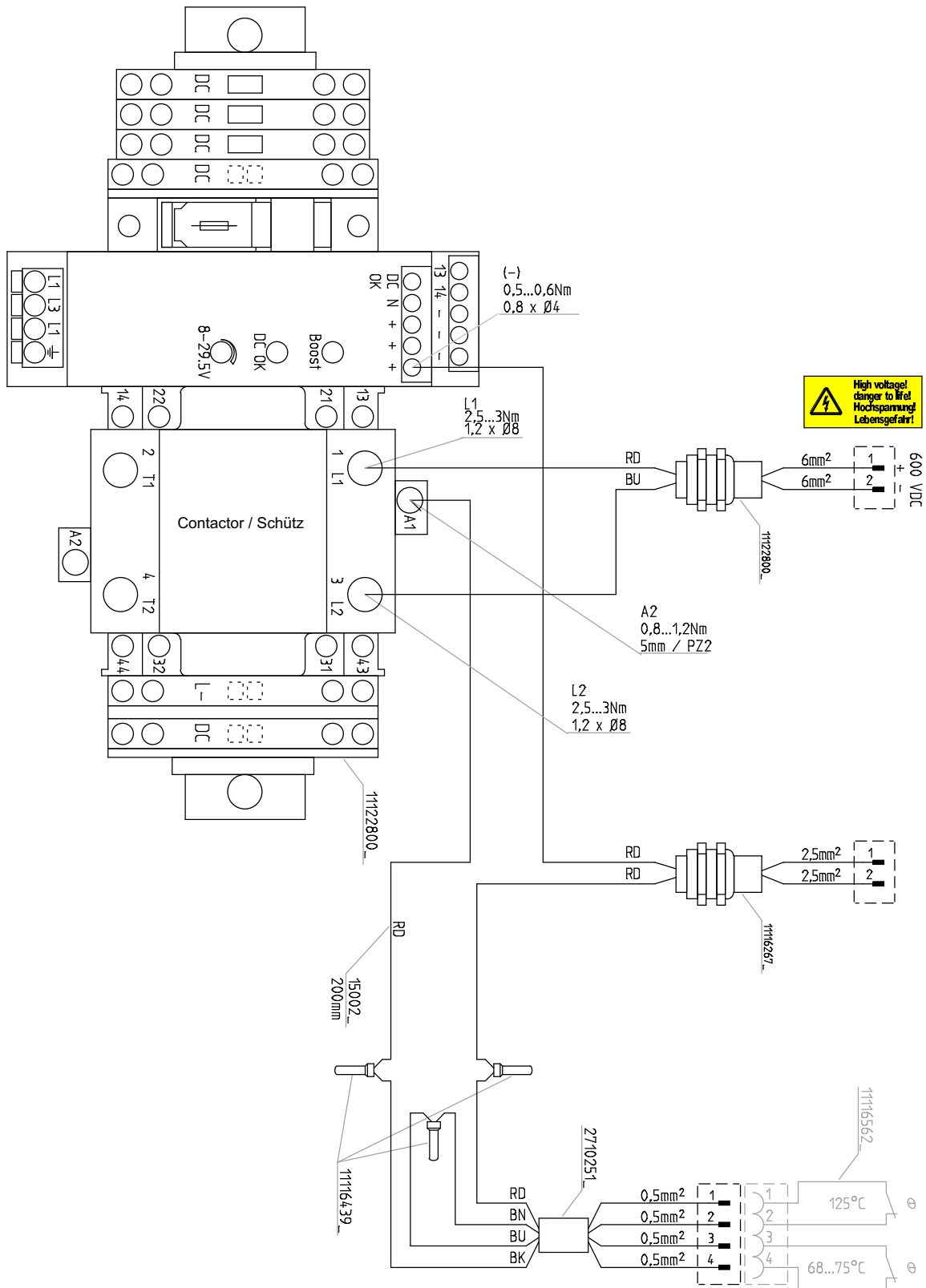


Fig. 606 Housing removal for devices Thermo DC 20 kW with DC-DC converter (heater ident. no. acc. to model plate 11117083B)

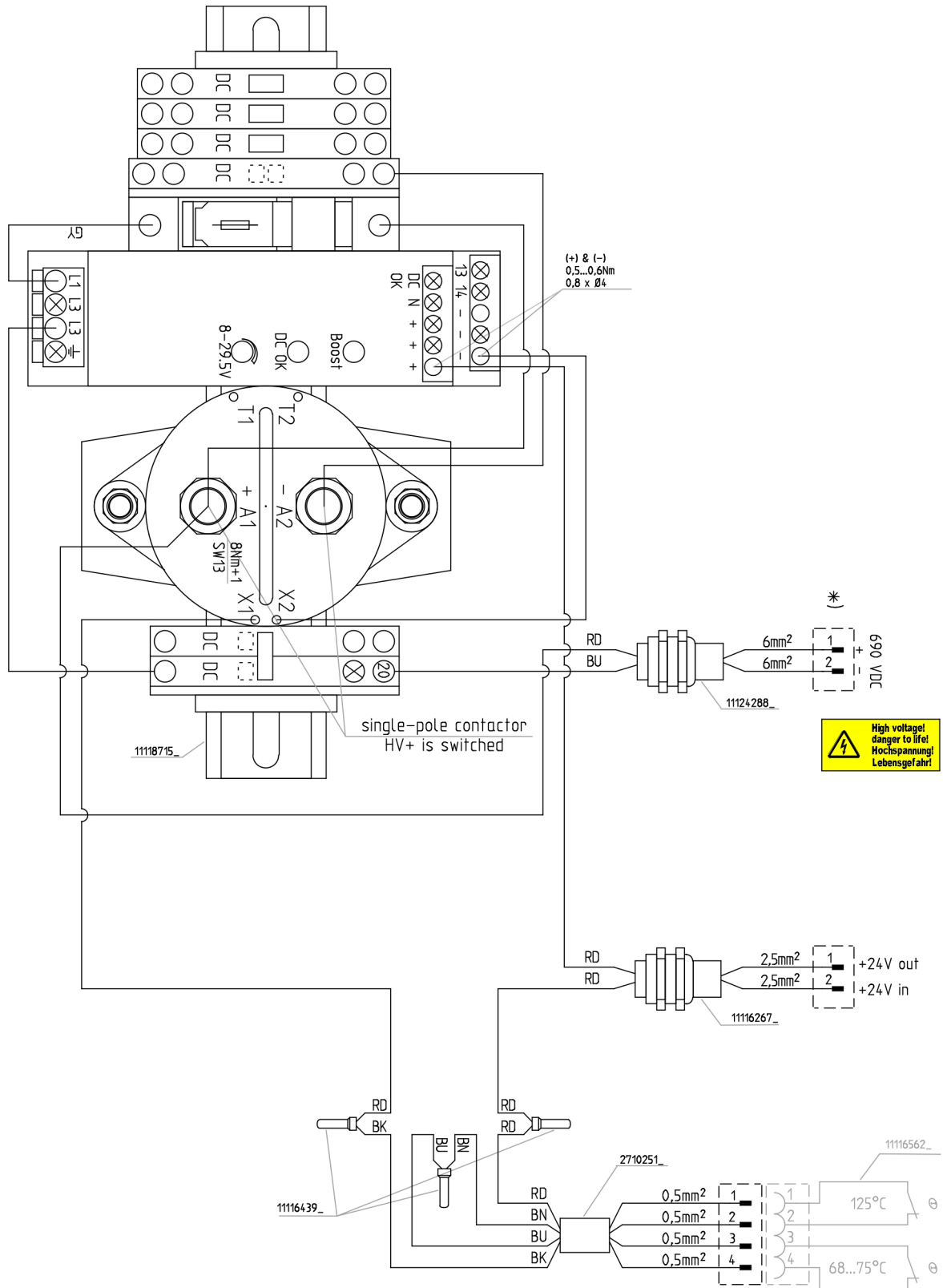


Fig. 607 Housing removal for devices Thermo DC 20 kW with DC-DC converter (heater ident. no. acc. to model plate 11117083C/D)

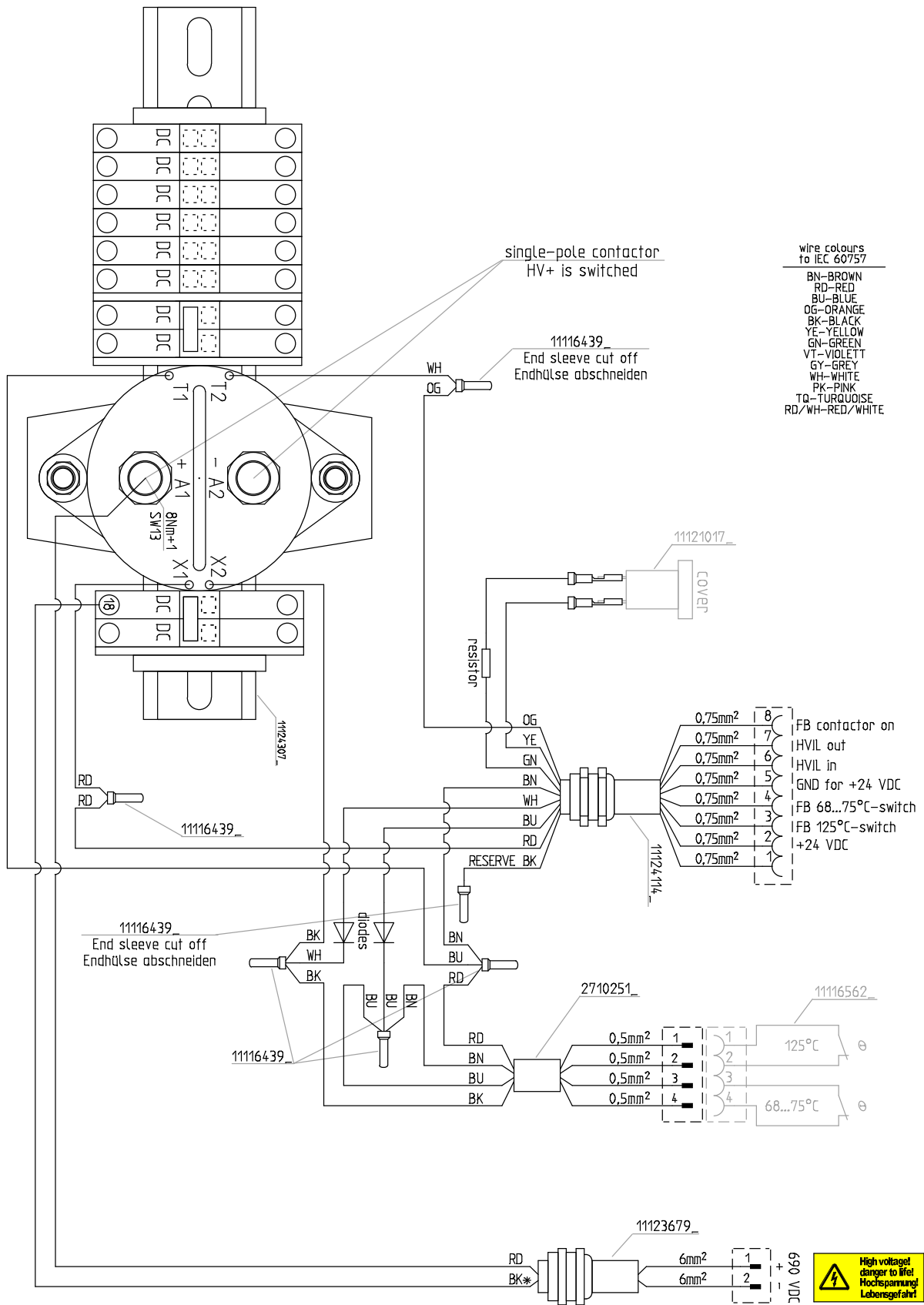


Fig. 608 Housing removal for devices Thermo DC 20 kW without DC-DC converter, with HVIL contact at the hood (heater ident. no. acc. to model plate 11125620B)

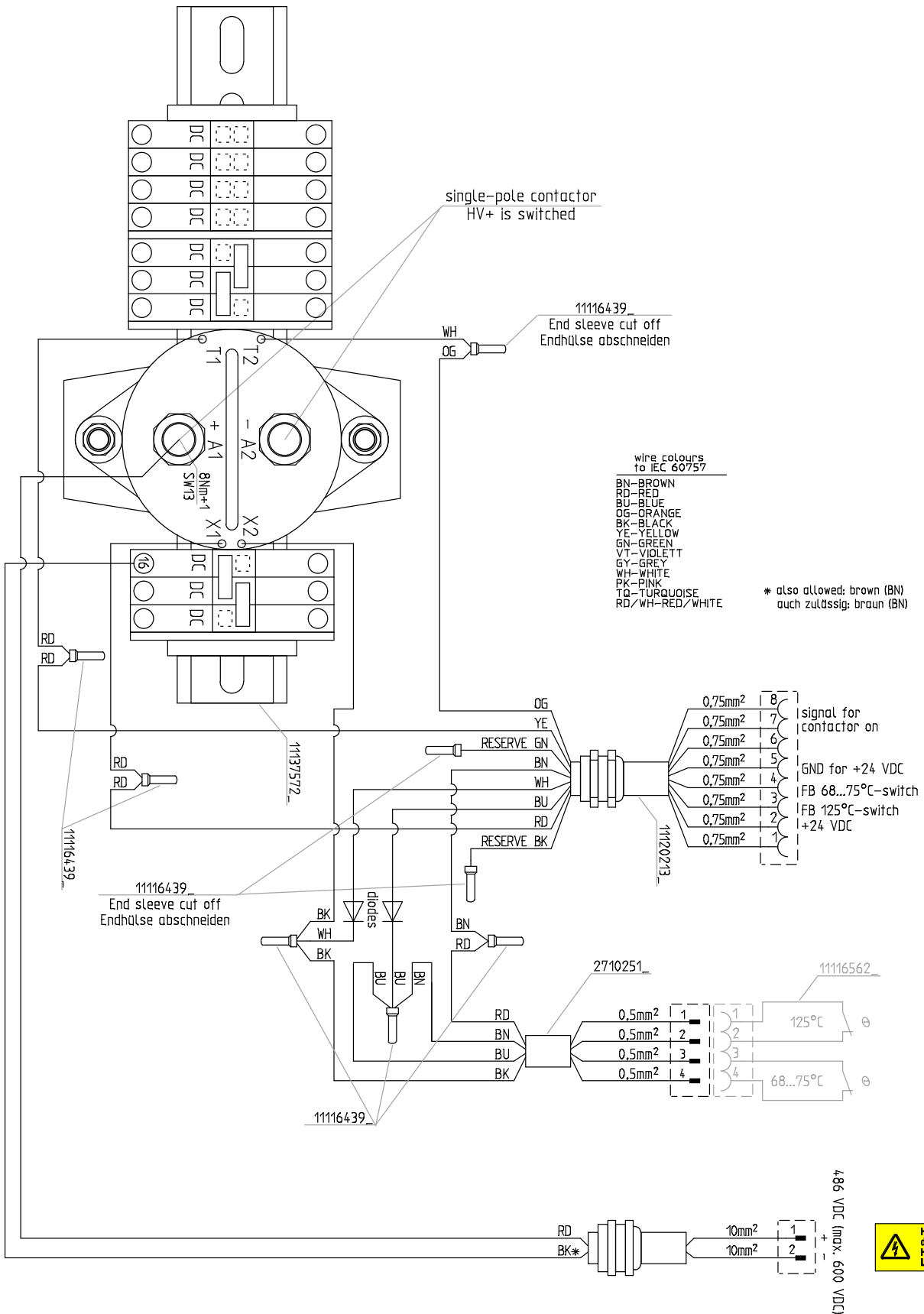


Fig. 609 Housing removal for devices Thermo DC 20 kW without DC-DC converter (heater ident. no. acc. to model plate 11126153A/B)

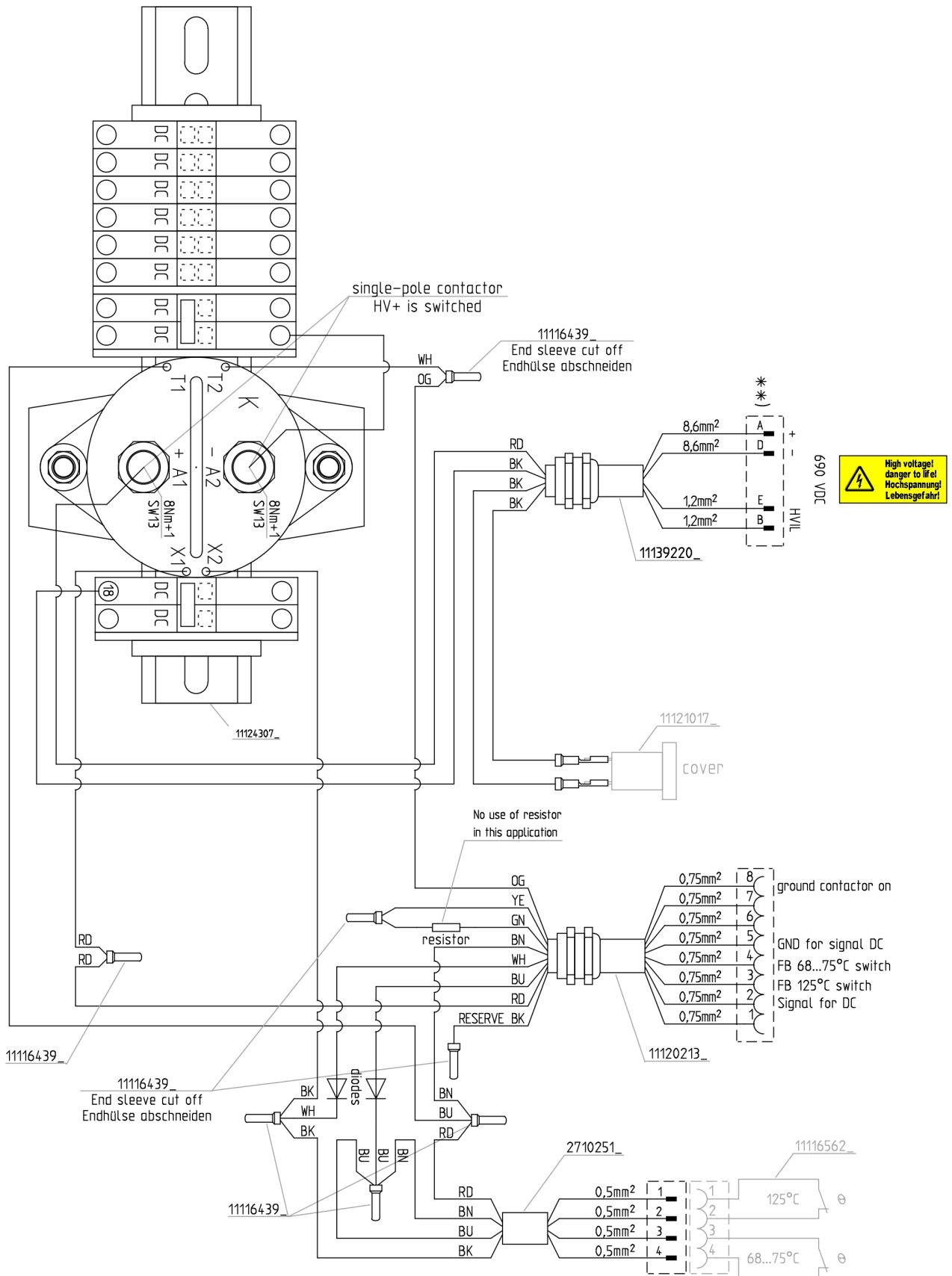


Fig. 610 Housing removal for devices Thermo DC 20 kW without DC-DC converter
(heater ident. no. acc. to model plate 11139411A/B)

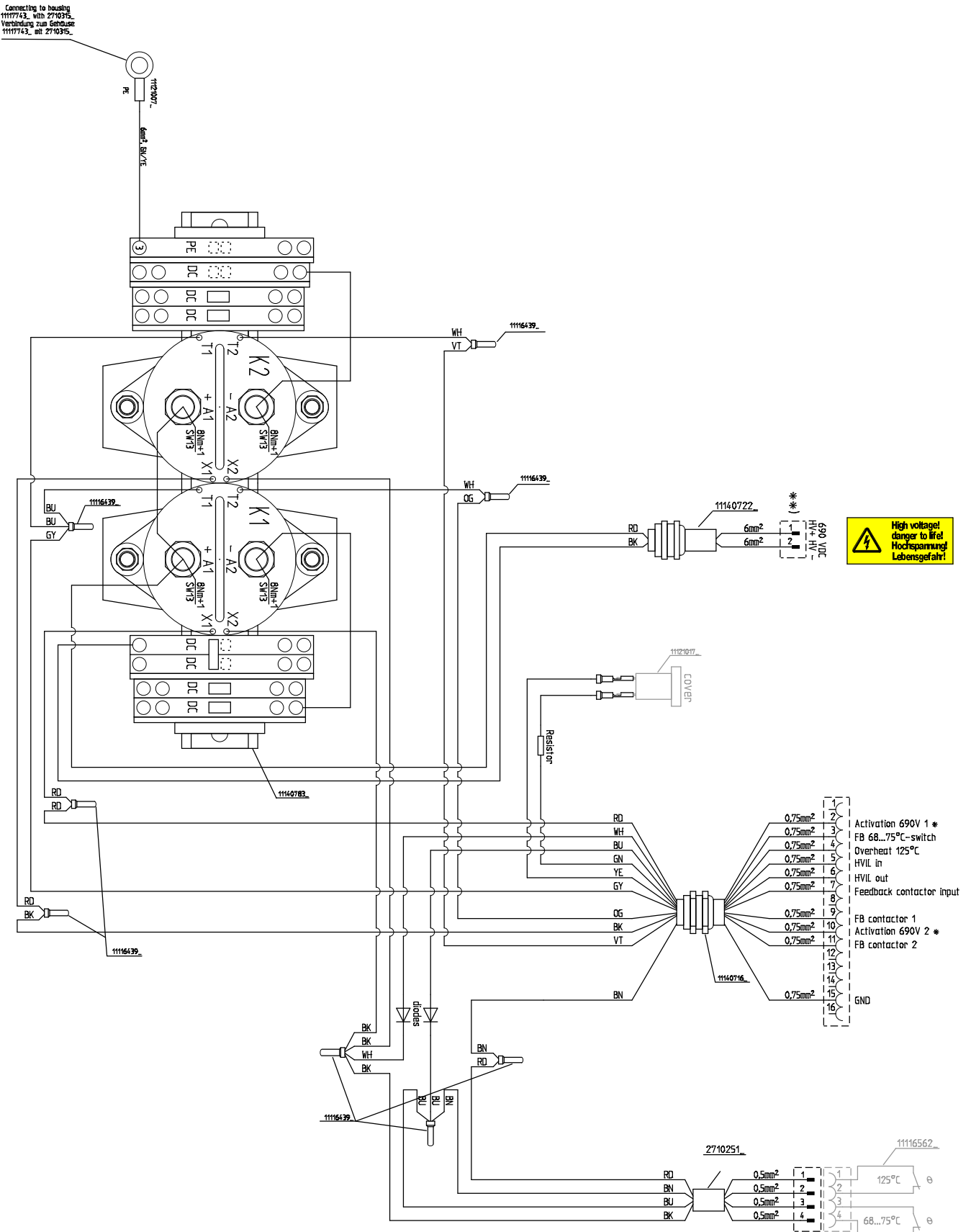


Fig. 611 Housing removal for devices Thermo DC 7 / 14 / 20 kW without DC-DC converter
(heater ident. no. acc. to model plate 11141607A)

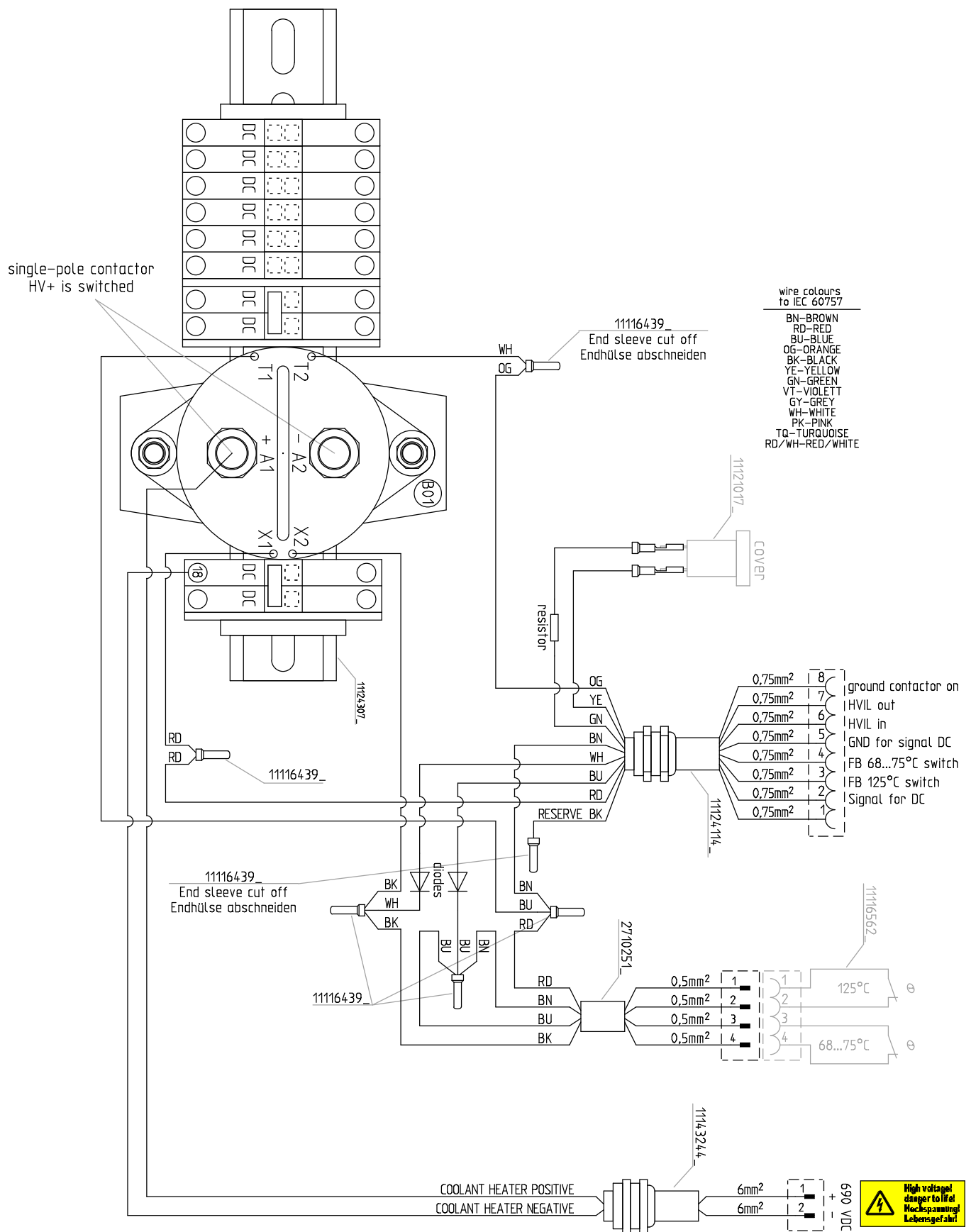


Fig. 612 Housing removal for devices Thermo DC 20 kW without DC-DC converter
(heater ident. no. acc. to model plate 11144160A)

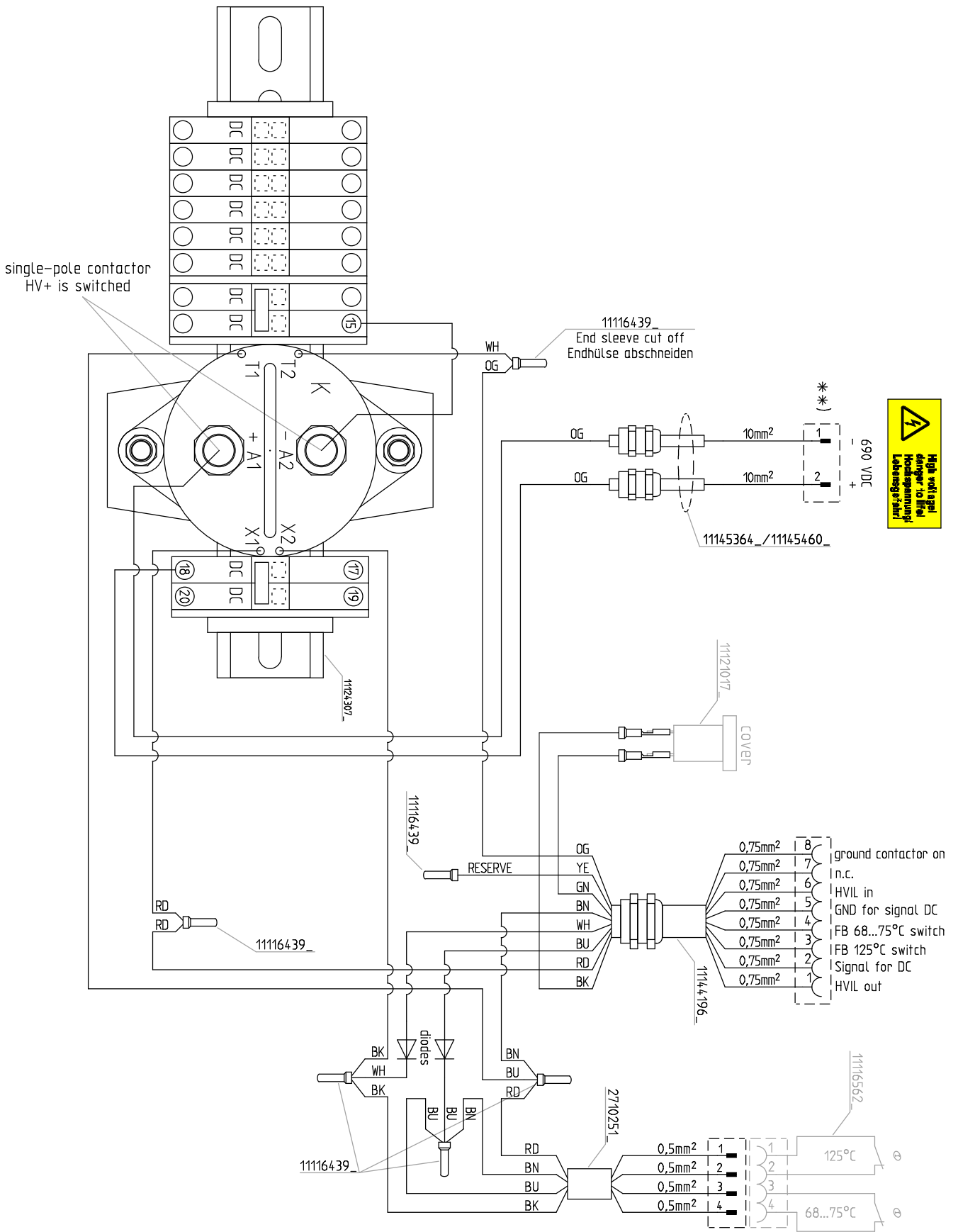


Fig. 613 Housing removal for devices Thermo DC 20 kW without DC-DC converter
(heater ident. no. acc. to model plate 11144705B)

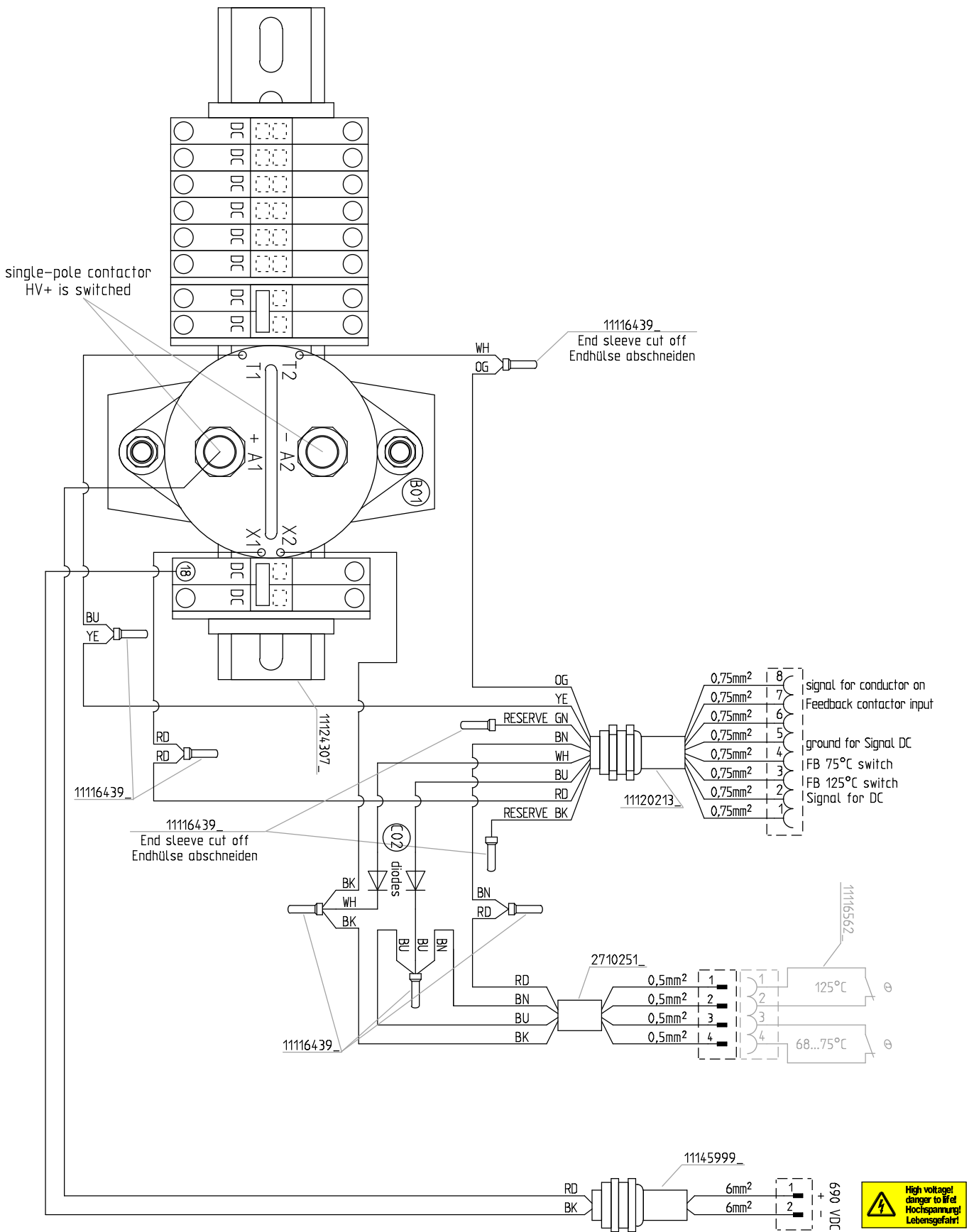


Fig. 614 Housing removal for devices Thermo DC 20 kW without DC-DC converter (heater ident. no. acc. to model plate 11146105A)



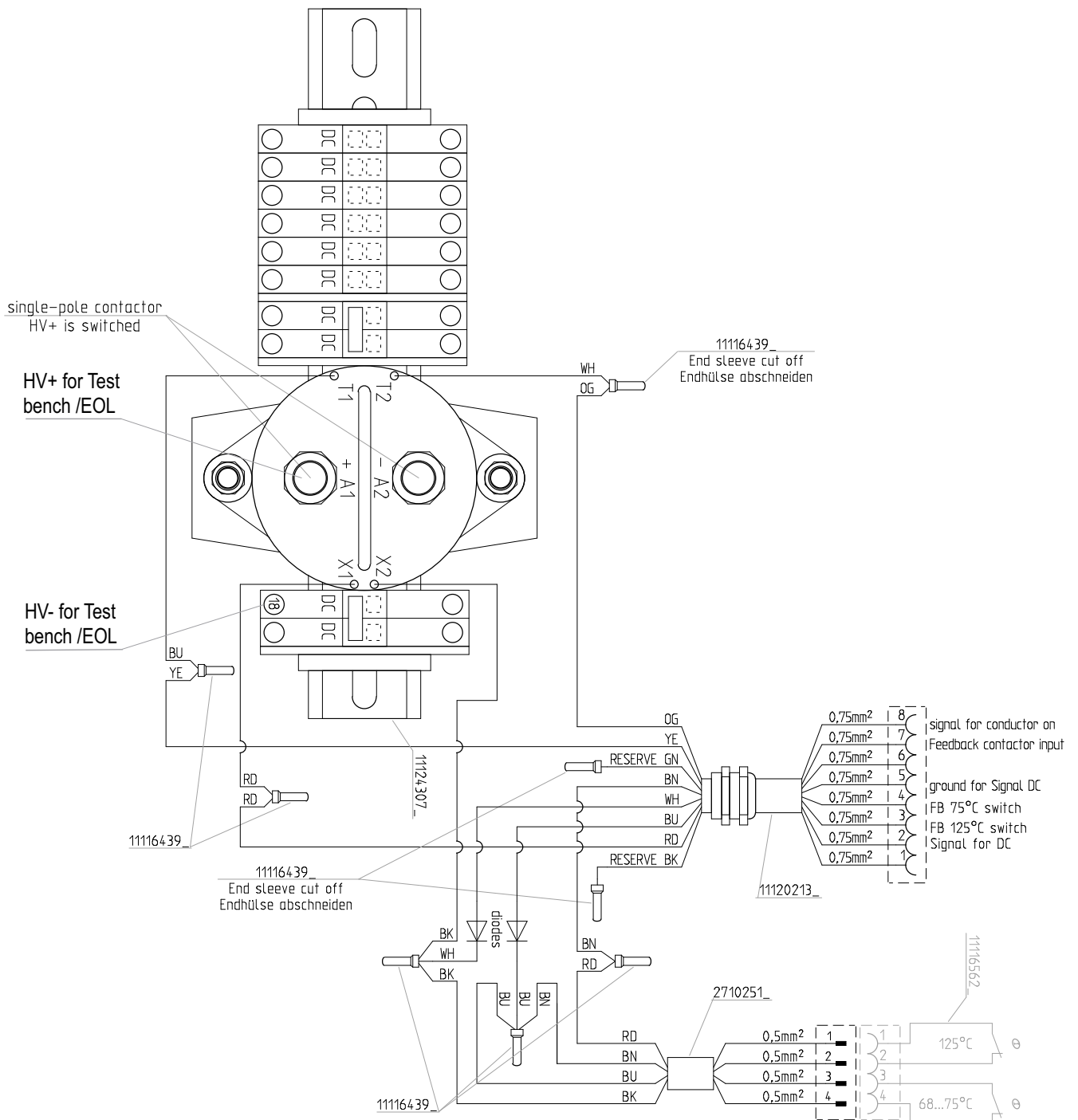


Fig. 615 Housing removal for devices Thermo DC 20 kW without DC-DC converter (heater ident. no. acc. to model plate 11146151A)

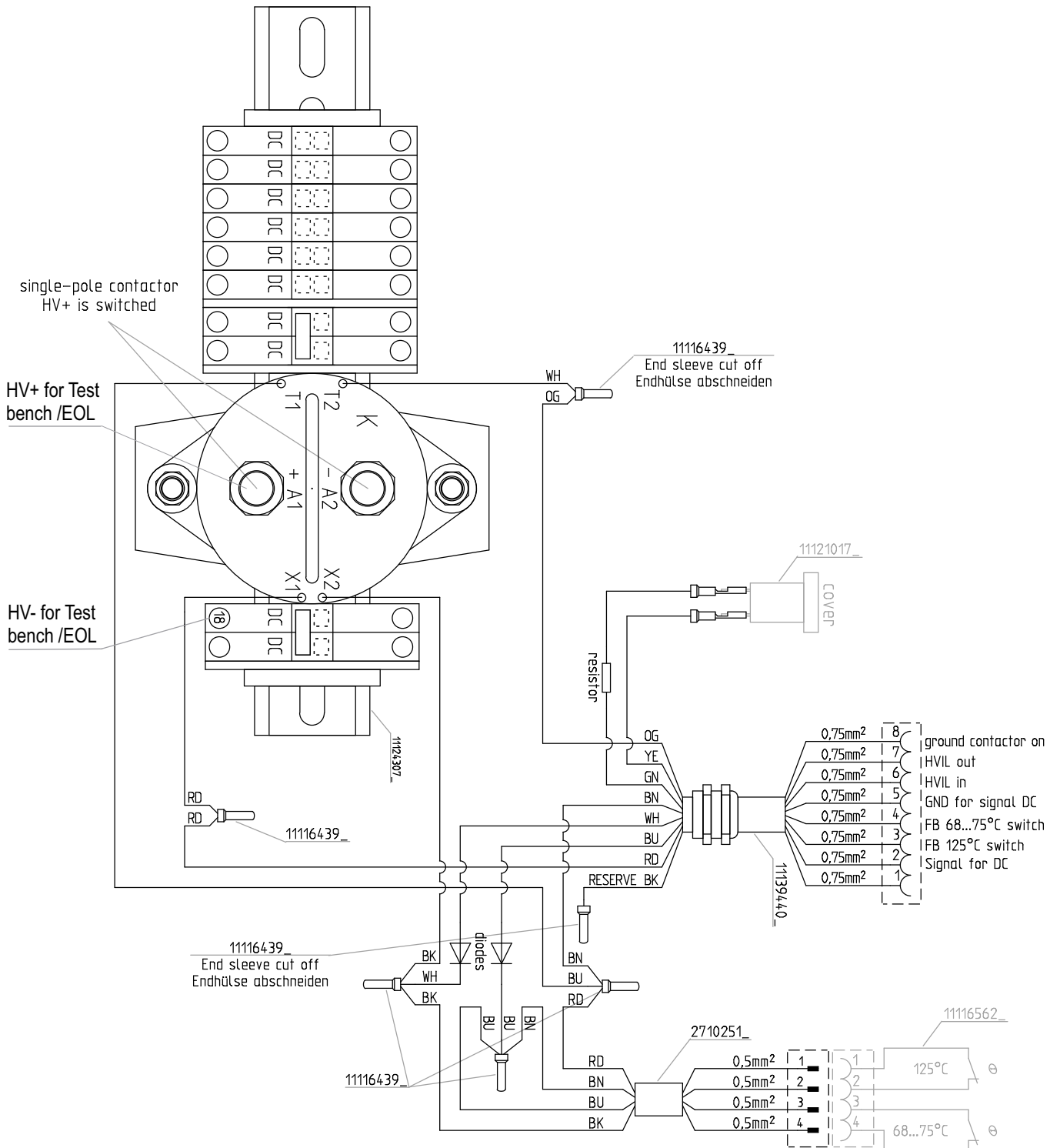


Fig. 616 Housing removal for devices Thermo DC 20 kW without DC-DC converter (heater ident. no. acc. to model plate 11148103B)

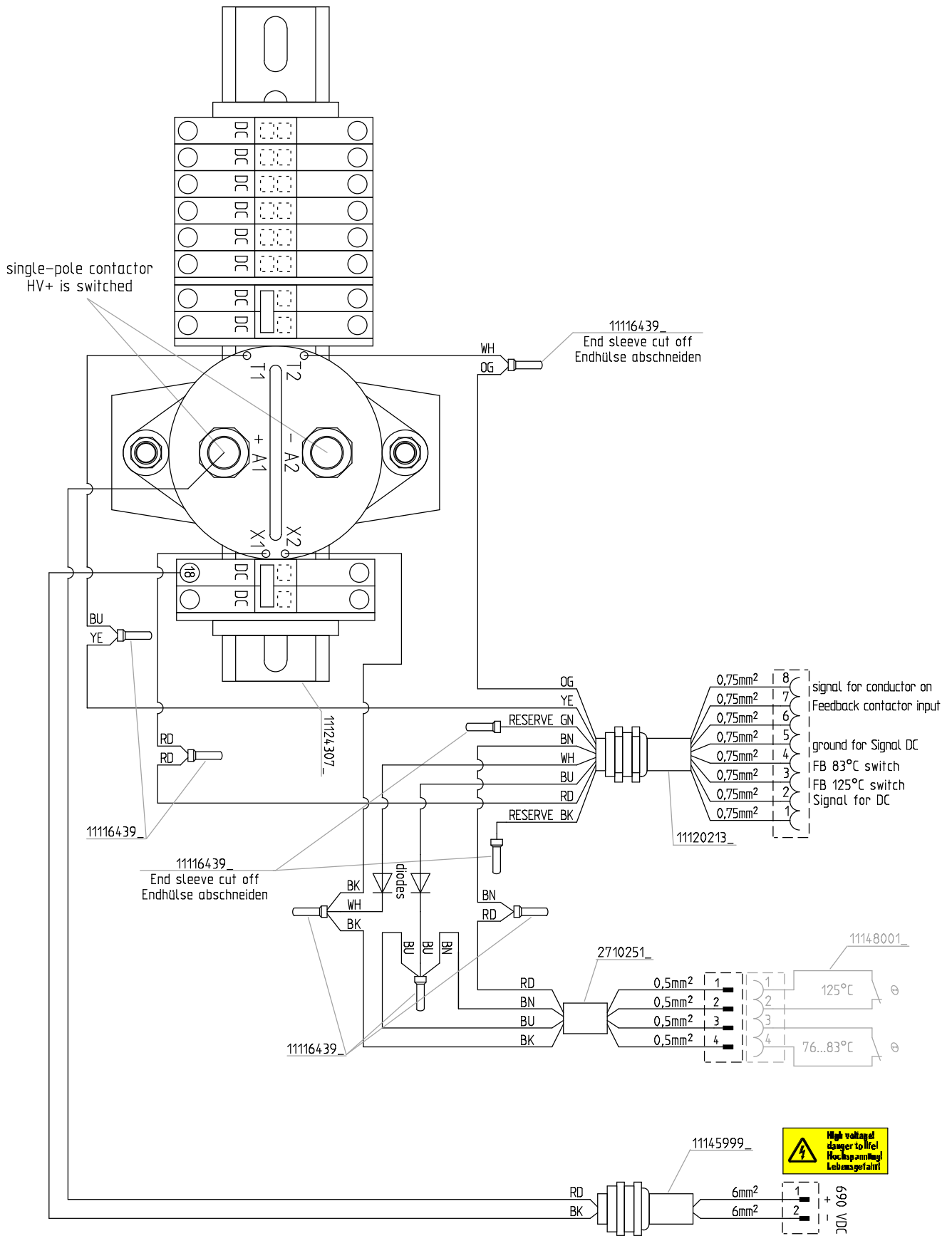


Fig. 617 Housing removal for devices Thermo DC 20 kW without DC-DC converter (heater ident. no. acc. to model plate 11148246A)

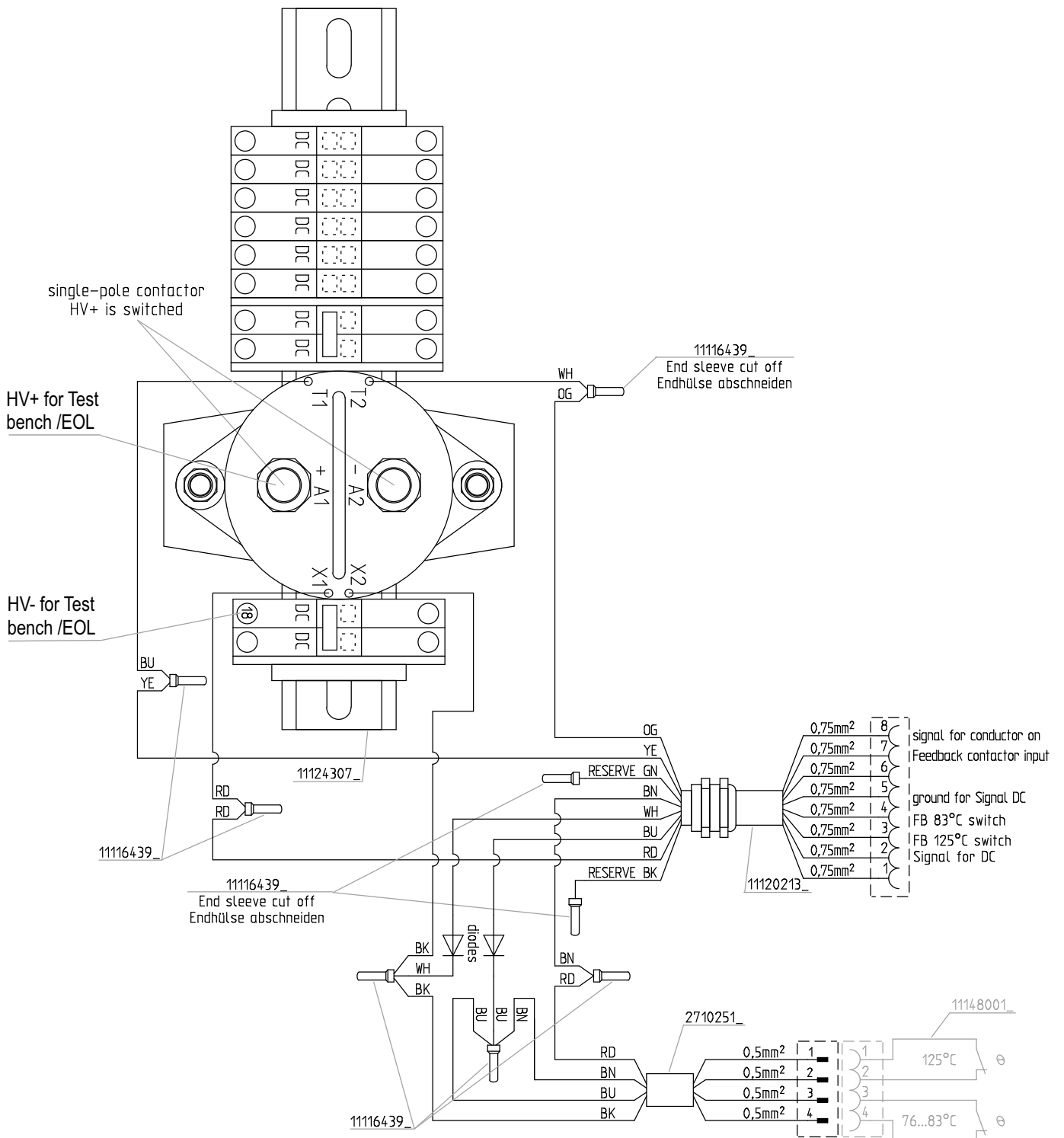


Fig. 618 Housing removal for devices Thermo DC 20 kW without DC-DC converter (heater ident. no. acc. to model plate 11147978B)

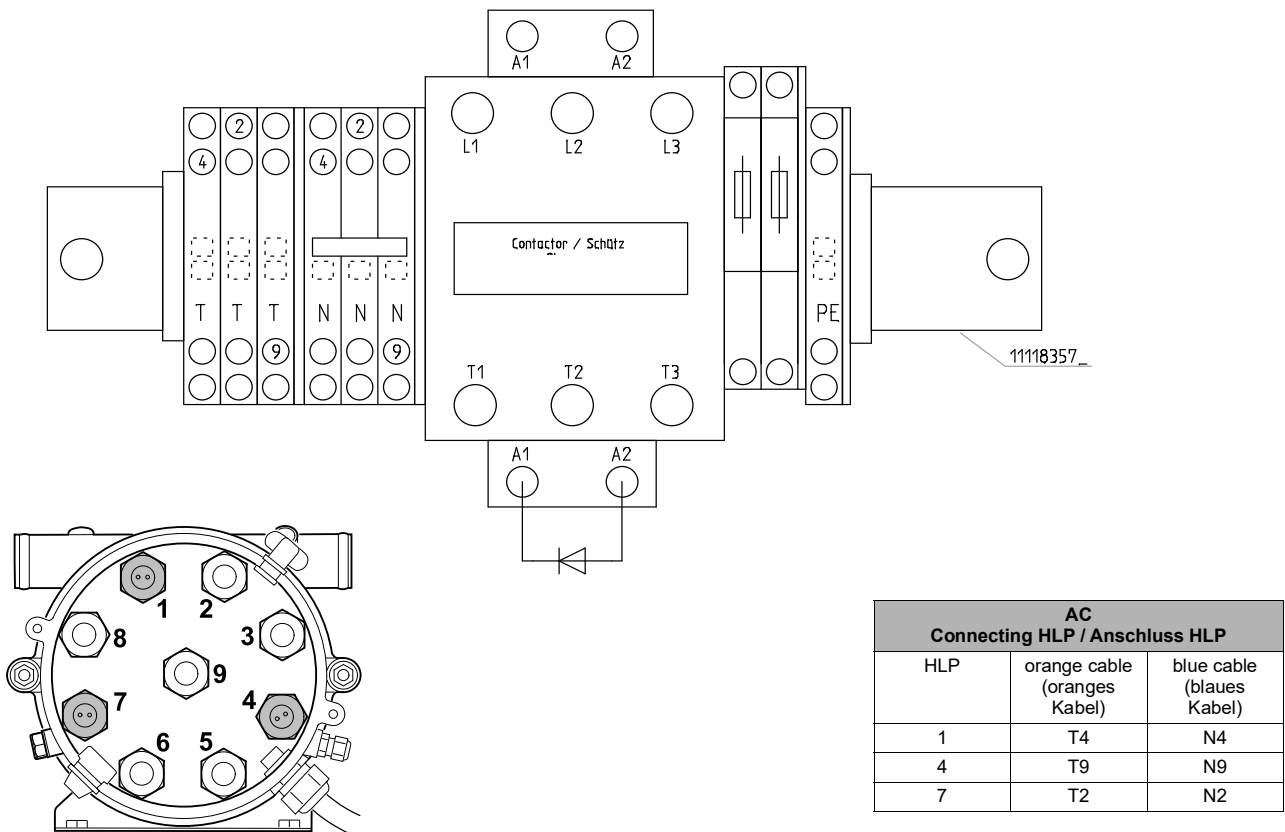


Fig. 619 Small distribution board removal for devices Thermo AC 7 kW without converter (heater ident. no. acc. to model plate 11117427A)

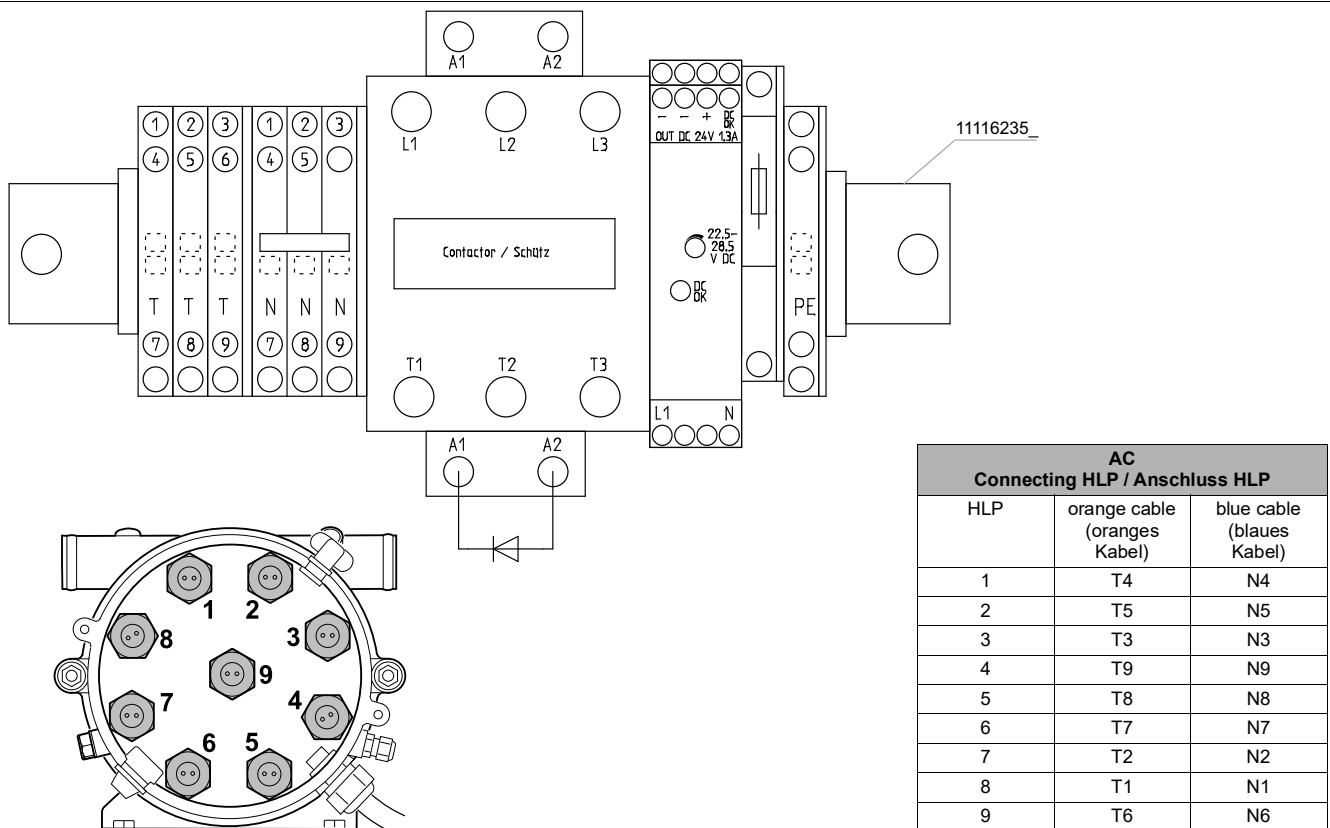


Fig. 620 Small distribution board removal for devices Thermo AC 20 kW with AC-DC converter (heater ident. no. acc. to model plate 11116255A)

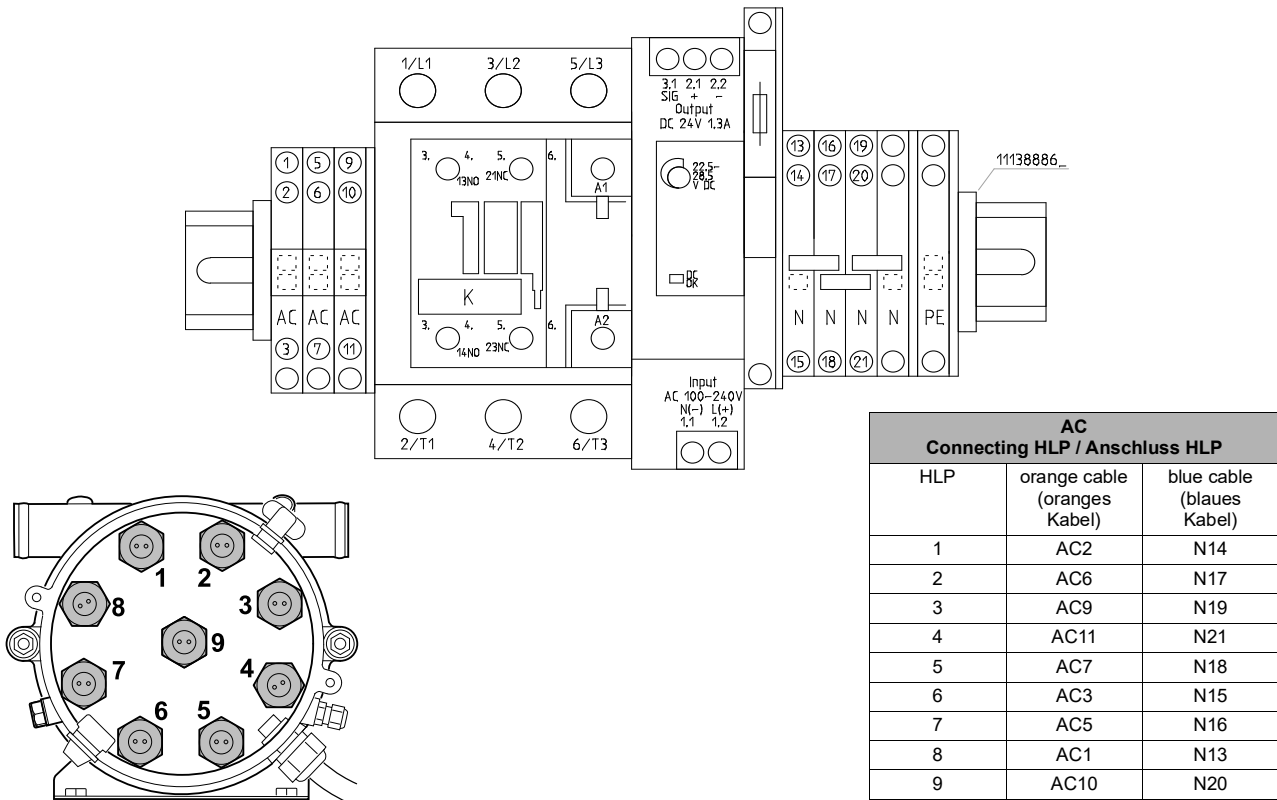


Fig. 621 Small distribution board removal for devices Thermo AC 20 kW with AC-DC converter (heater ident. no. acc. to model plate 11140183A)

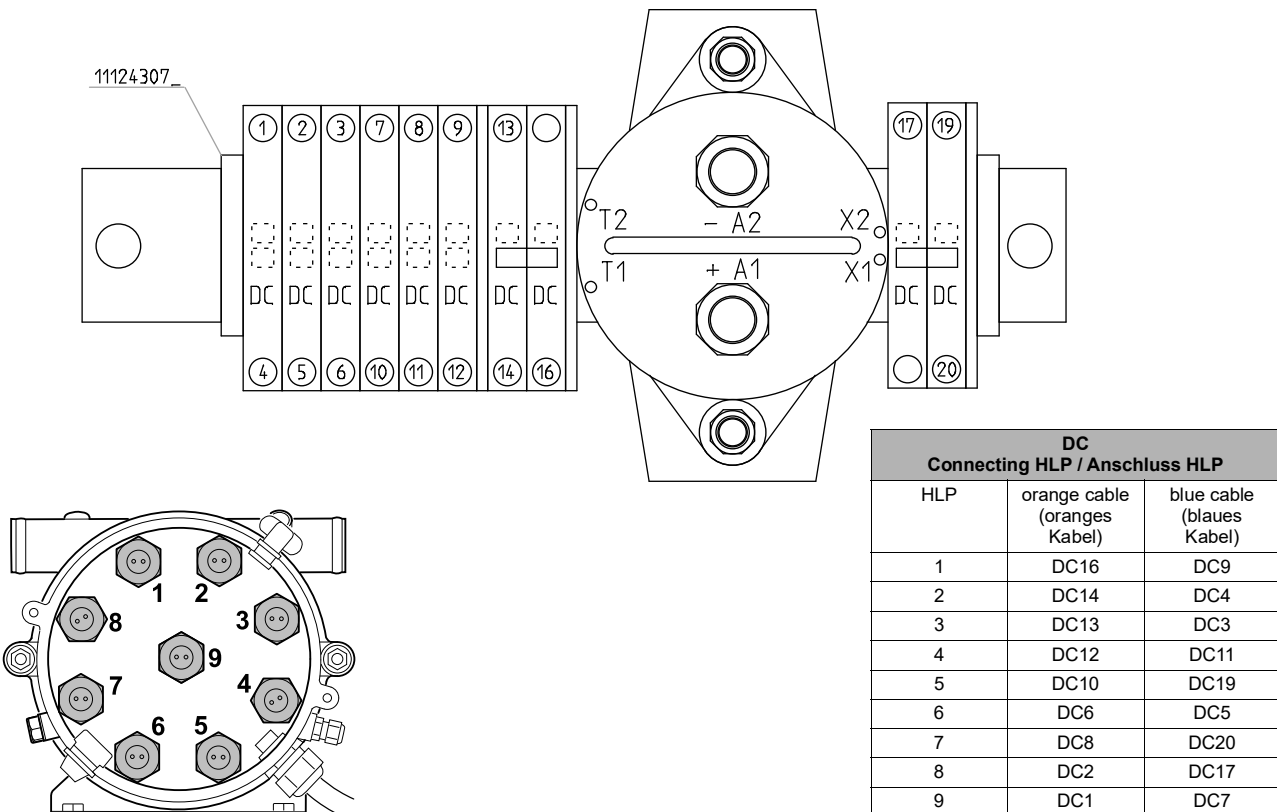


Fig. 622 Small distribution board removal for devices Thermo DC 20 kW without converter (heater ident. no. acc. to model plate 11122596B, 11122677B, 11125620A and 11139411)

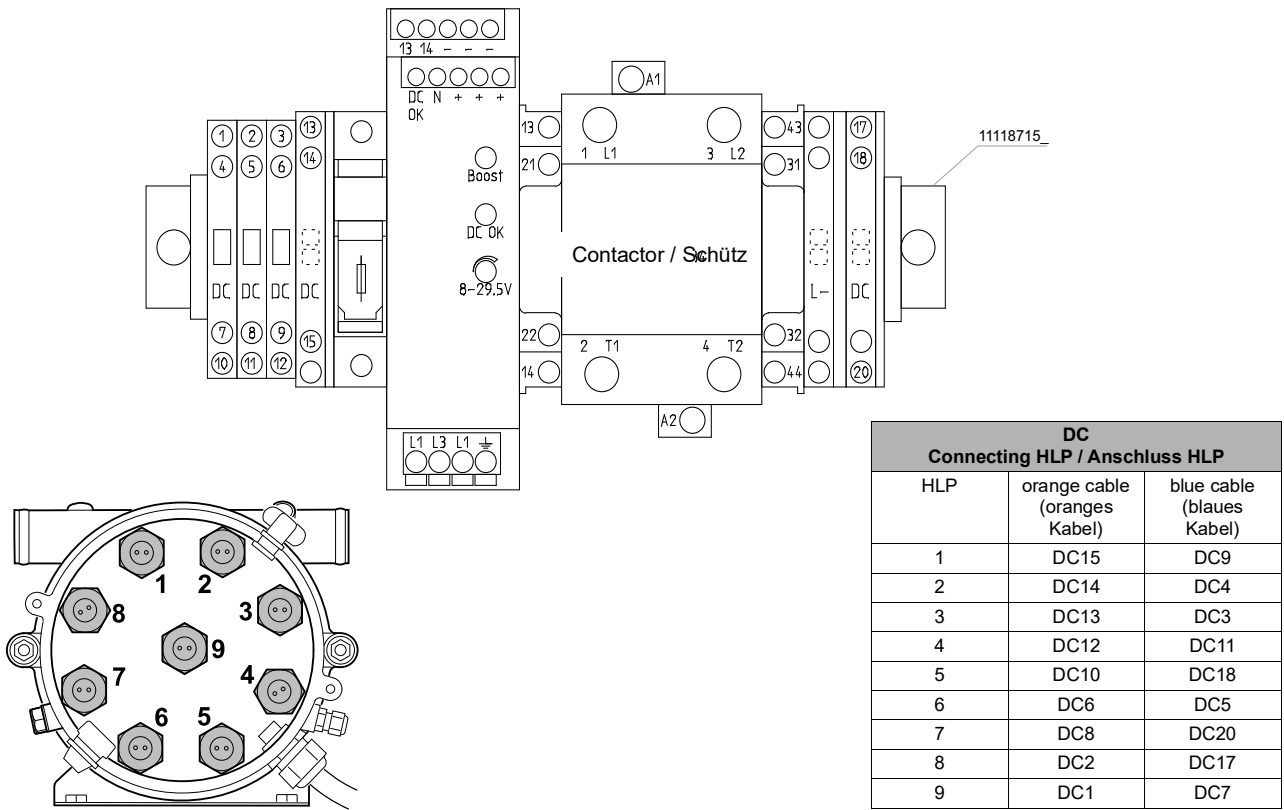


Fig. 623 Small distribution board removal for devices Thermo DC 20 kW with DC-DC converter (heater ident. no. acc. to model plate 11117083B)

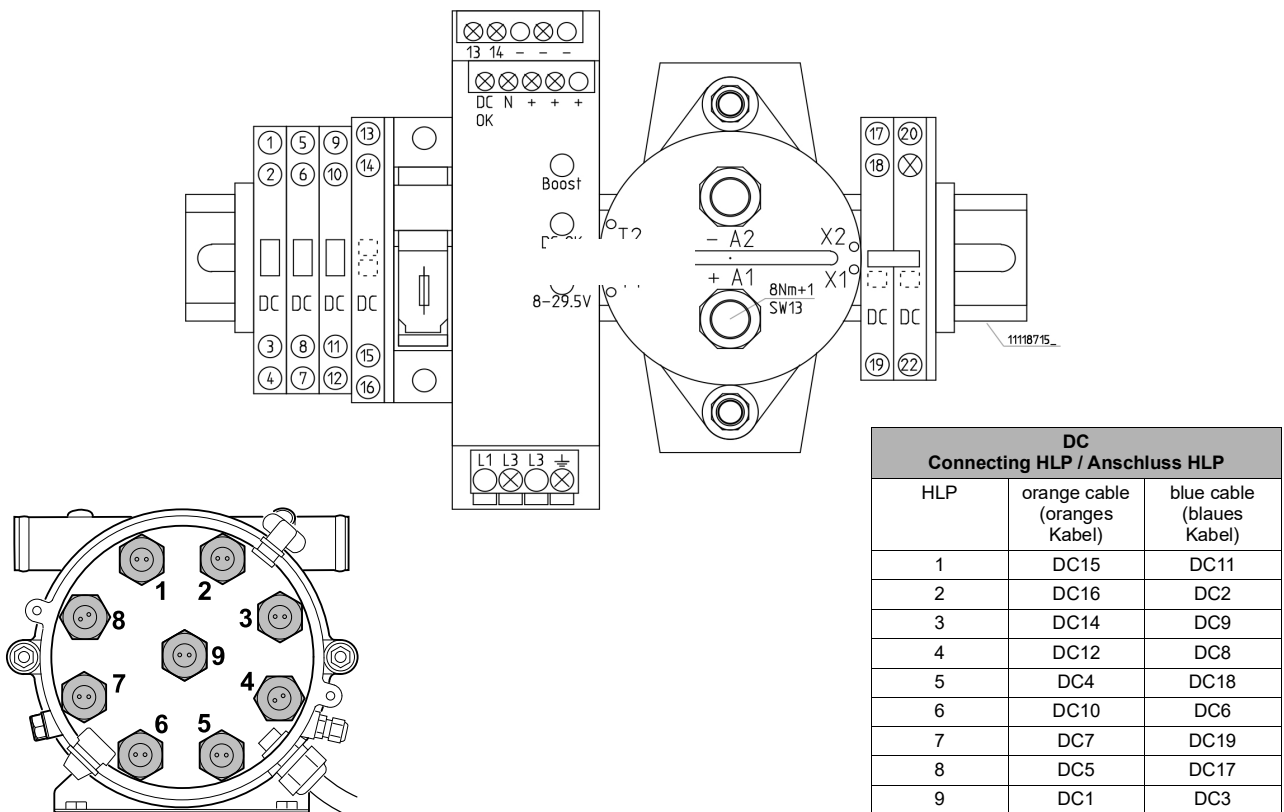


Fig. 624 Small distribution board removal for devices Thermo DC 20 kW with DC-DC converter (heater ident. no. acc. to model plate 11117083C)

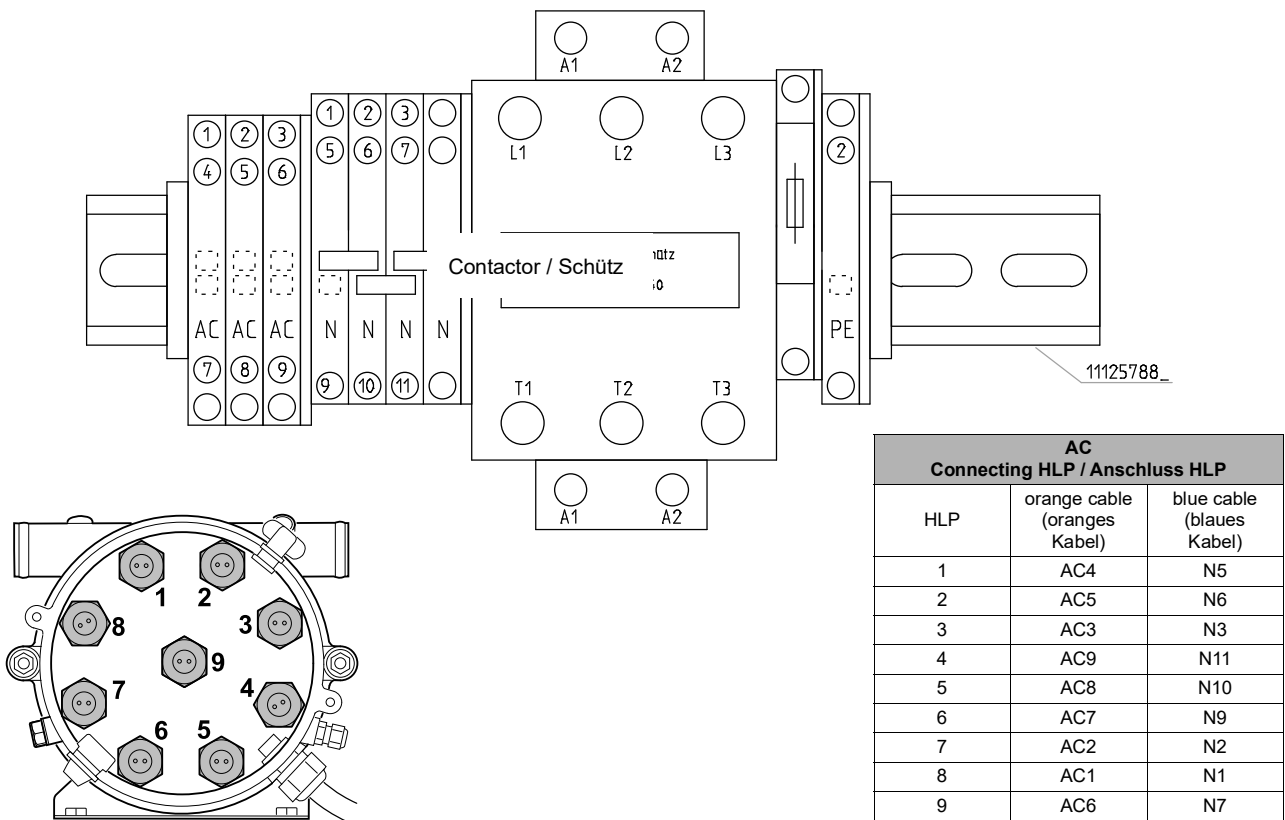


Fig. 625 Small distribution board removal for devices Thermo DC 20 kW without converter
(heater ident. no. acc. to model plate 11125621A)

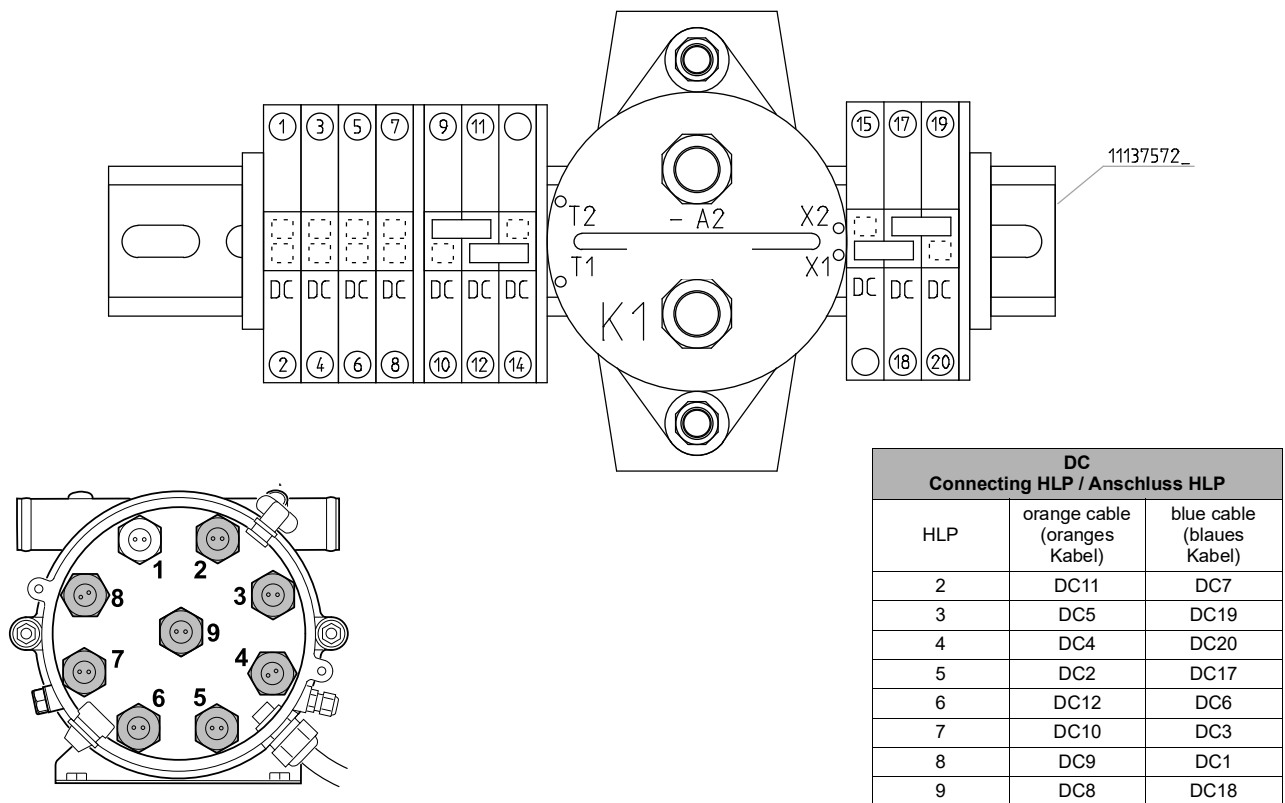


Fig. 626 Small distribution board removal for devices Thermo DC 20 kW without converter
(heater ident. no. acc. to model plate 11126153A)

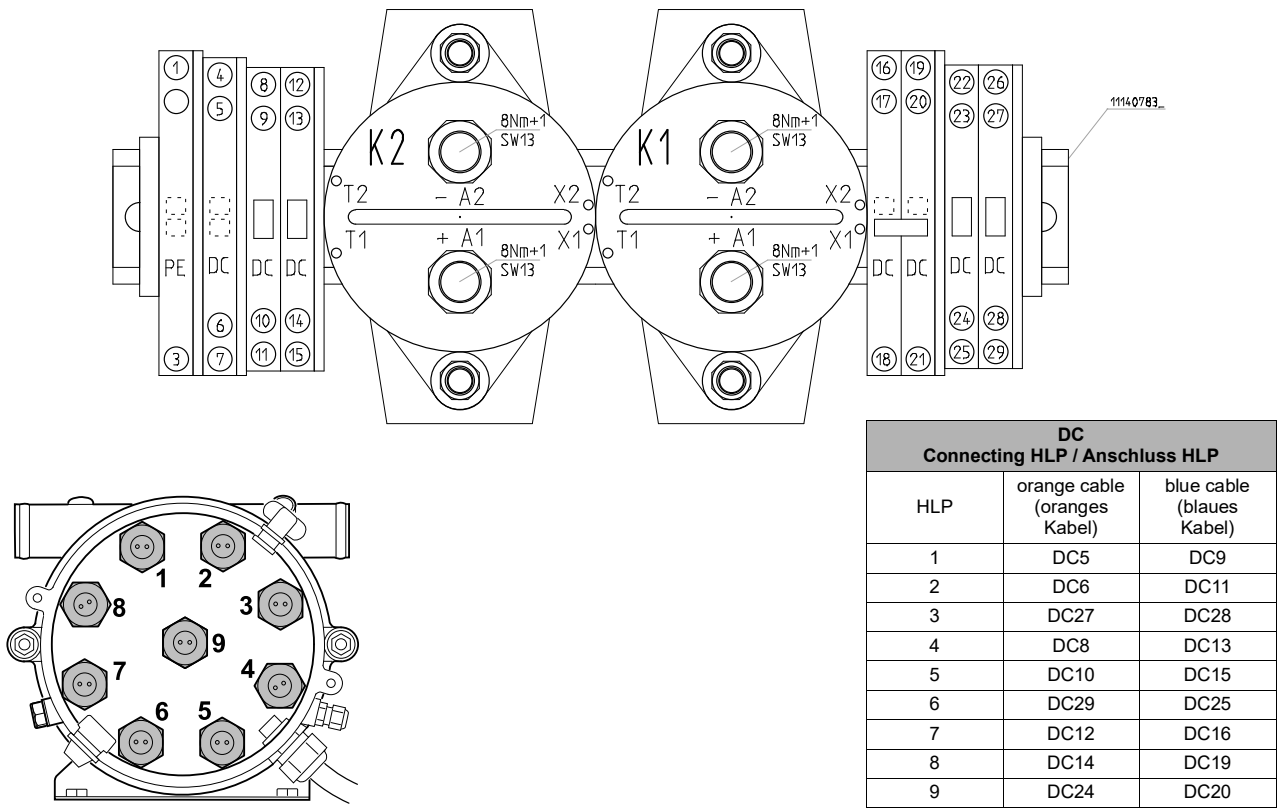


Fig. 627 Small distribution board removal for devices Thermo DC 7 / 14 / 20 kW without converter (heater ident. no. acc. to model plate 11141607A)

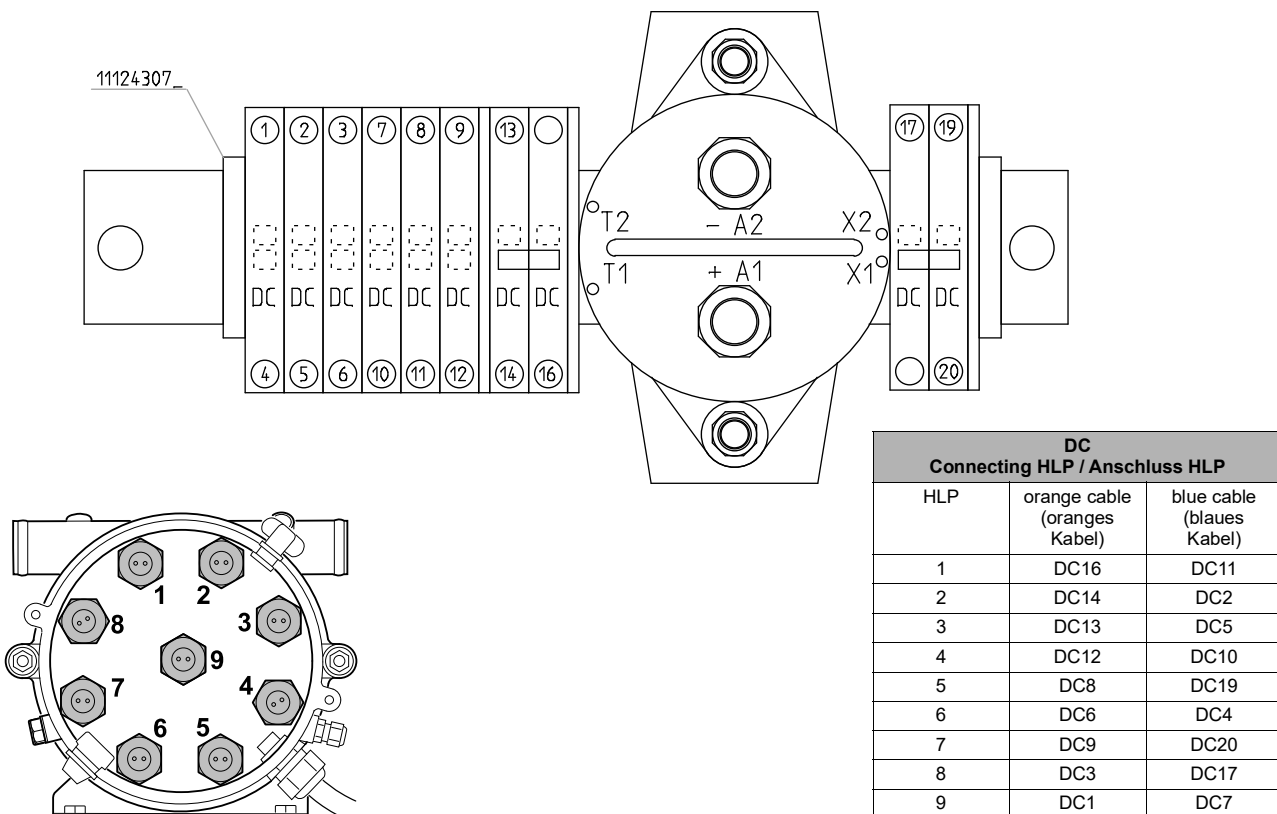


Fig. 628 Small distribution board removal for devices Thermo DC 20 kW RAIL (heater ident. no. acc. to model plate 11140458B)

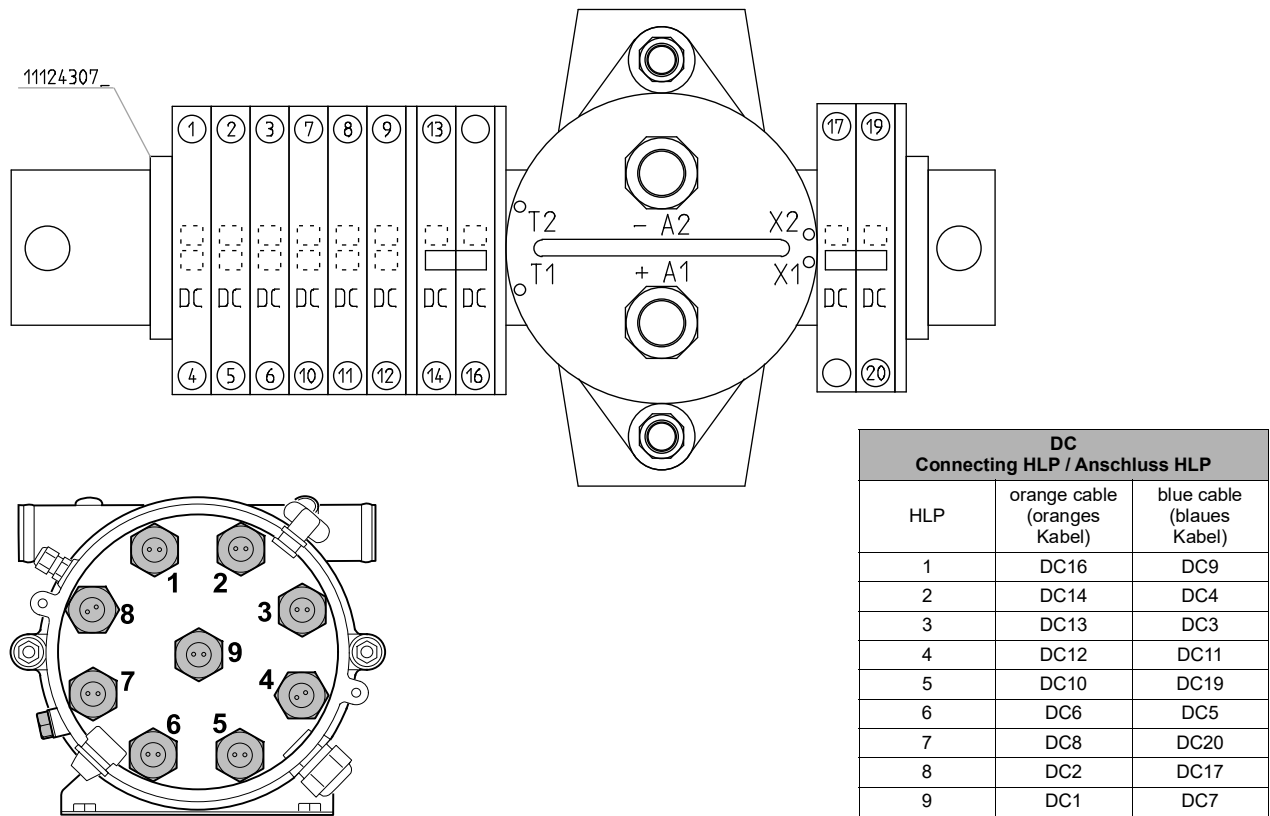


Fig. 629 Small distribution board removal for devices Thermo DC 20 kW without converter (heater ident. no. acc. to model plate 11144160A, 11144705B, 11148103B)

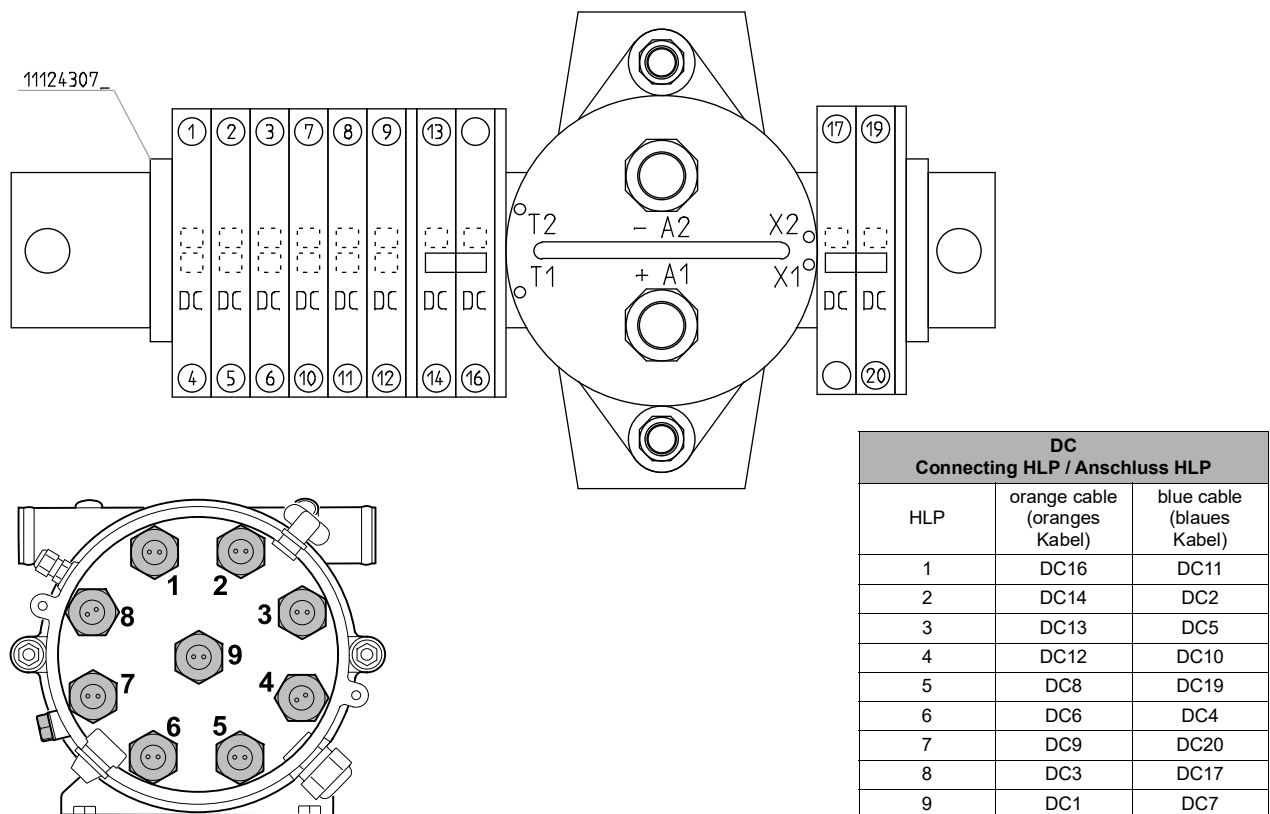


Fig. 630 Small distribution board removal for devices Thermo DC 20 kW without converter (heater ident. no. acc. to model plate 11148246A, 11146151A, 11146105A, 11147978B)

7 Servicing

7.1 General



The safety information and regulations of Chapter 1 (see 1.6) must be observed.

7.2 Heater servicing

In order to achieve a lasting functional reliability of the heater, the heater should be periodically maintained.

7.2.1 Periodical heater maintenance

Scope and intervals of the heater periodical maintenance can be found in the maintenance plan contained in the Appendix A of this Workshop Manual.

8 Components and heater removal and installation

8.1 General



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



Before starting the work at the heater, it is to make voltageless and this state must be ensured for the duration of the work (consider 1.6.3 !).

ATTENTION:

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

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

NOTE:

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

In the figures of the procedures following icon is used:



Symbol tightening torque:
Features in graphics parts (e.g. nuts, bolts) that are to be mounted with a specific tightening torque. The values for the tightening torque are at the symbol and are binding.

8.2 Temperature guards (temperature limiter, control thermostat) removal/installation.

Removal

1. Establish voltage-free state of the heater and secure it for duration of the work (**Observe 1.6.3 !**).
2. Disconnect temperature guards plug (1, Fig. 801).
3. Remove the rubber cap of the temperature limiter (4).
4. Using a screw driver, lever off retaining spring (3) and remove the temperature limiter (2).
5. Remove the protection cap (6) of the control thermostat (7).
6. Screw out by hand the control thermostat (7).

NOTE:

The control thermostat is screwed into the screw-in socket, which should not be loosened.

Installation

1. Screw the control thermostat (7, Fig. 801) by hand into the coolant inlet.
2. Install protection cap (6).
3. Slide rubber cap (4) of the temperature limiter back

- until it can be put in its installation position.
4. Position temperature limiter (2) in the reception neck (5) and push in the retaining clip (3).

ATTENTION:

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

NOTE:

The rubber cap (4) must be fitted in such a way that its cable sleeve runs in the direction of the heater's centre line. After the rubber cap has been fitted, the cable in the sleeve must be adjusted without tension.

5. Install the rubber cap.
After the rubber cap has been installed, the cable must be aligned in the cable sleeve so it is tension-free. Connection cables must not be routed over the reset button.
6. Reconnect the temperature guards plug (1).
7. Restore the power supply as required.

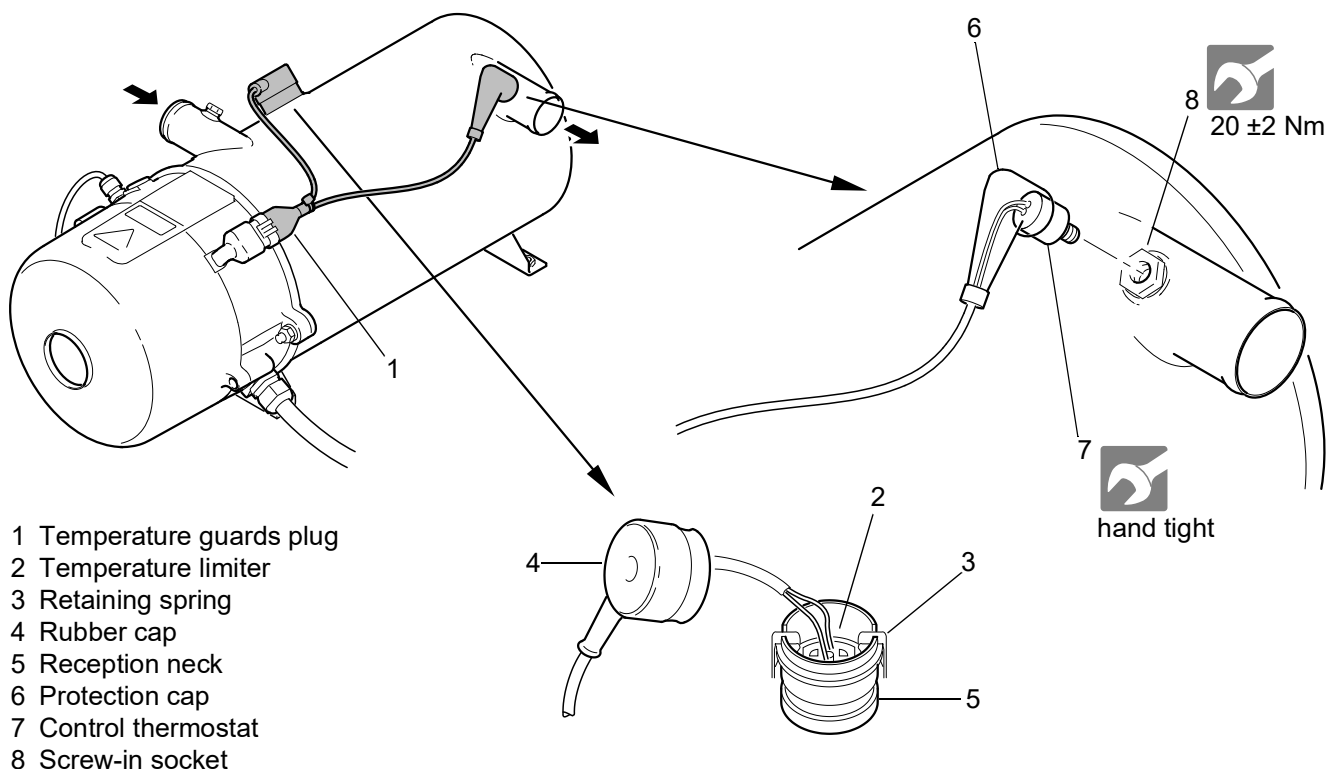


Fig. 801 Removal and installation of the temperature guards

8.3 Hood removal/installation

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

- Small distribution board (load contactor AC/DC)
- Heating cartridges
- HVIL contact

Removal

1. Establish voltage-free state of the heater and secure it for duration of the work (**Observe 1.6.3 !**).
2. Loosen screws (2, Fig. 803, Sheet 1).

NOTE:

The screws remain in the hood.

3. Remove hood (1) with stabilizer (3) from heater.

Installation

1. Place stabilizer (3, Fig. 803, Sheet 1) onto the small distribution board (16).
2. Place hood (1) in assembly position, turn in the screws (2) and tighten them.
3. Restore power supply.
4. Perform functional test.

8.4 Housing removal/installation (incl. cable connections)

Removal

1. Disconnect all cables from the vehicle electrical system to the heater.
2. Remove hood (see 8.3).
3. Disconnect cables connected to the small distribution board (16, Fig. 803, Sheet 1) by loosening the appropriate connections.

NOTE:

For connections to be disconnected, refer to wiring diagrams in Chapter 6, Fig. 601 thru Fig. 609 depending on the heater version.

Compare the heater ident. number under the wiring diagram with that on the model plate of your heater.

4. Remove the cable ties that bundle the single cables.
5. Disconnect temperature guards plug (8, Fig. 803, Sheet 2) from connection piece (13, Fig. 803, Sheet 1).
6. Loosen grounding screw (15) and remove it with washer (14) and vehicle grounding cable lug.
7. Remove nuts (6) and washers (7).

NOTE:

During the next step pay attention that the cables are not jammed or are still connected. "Danger of damage".

8. Remove housing from heater.

Installation

1. Position housing over the small distribution board onto the heater and then secure it using screws (6, Fig. 803, Sheet 1) and washers (7).
2. Screw grounding screw (15) with washer (14) and vehicle grounding cable lug into the housing (17) and tighten as required.
3. Install connection piece (13) of temperature guards onto the housing (17) if necessary.
4. Plug the temperature guards plug (8, Fig. 803, Sheet 2) into the connection piece (13) of temperature guards (note the snap-in noise).
5. Hook-up the supply cables to the corresponding terminals of the small distribution board (16, Fig. 803, Sheet 1) and tighten screws as required.

NOTE:

For connections to be established, refer to wiring diagrams in Chapter 6, Fig. 601 thru Fig. 609 depending on the heater version.

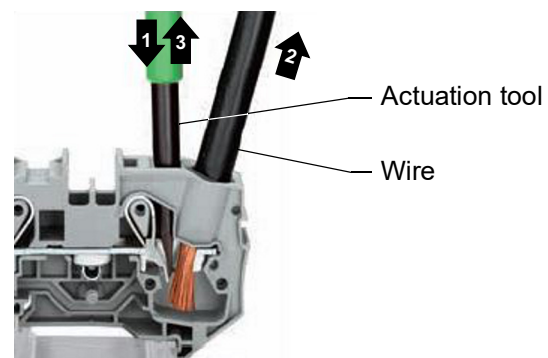
Compare the heater ident. number under the wiring diagram with that on the model plate of your heater.

6. Check the wiring again using the wiring diagram (see chapter 6).
7. Bundle single wires using cable ties.
8. Install hood (see 8.3).
9. Connect all supply cables to the vehicle electrical system, fix them if required.

8.5 Small distribution board removal/installation

NOTE:

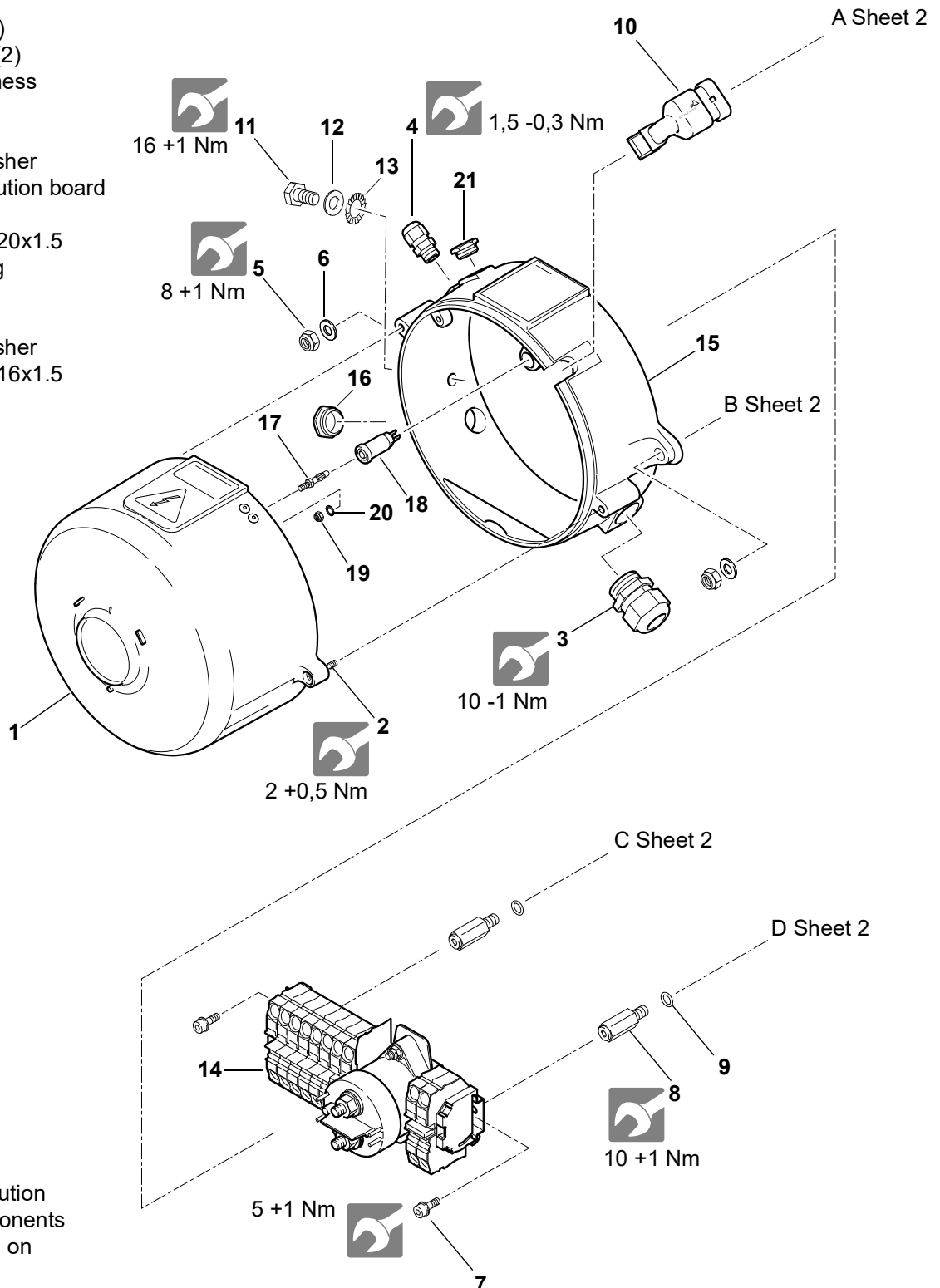
For loosening and connecting of cables to WAGO® terminals a special actuation tool is required. Learn more on the manufacturer's website regarding its proper handling.



Loosen wire: 1 - 2 - 3

Fig. 802

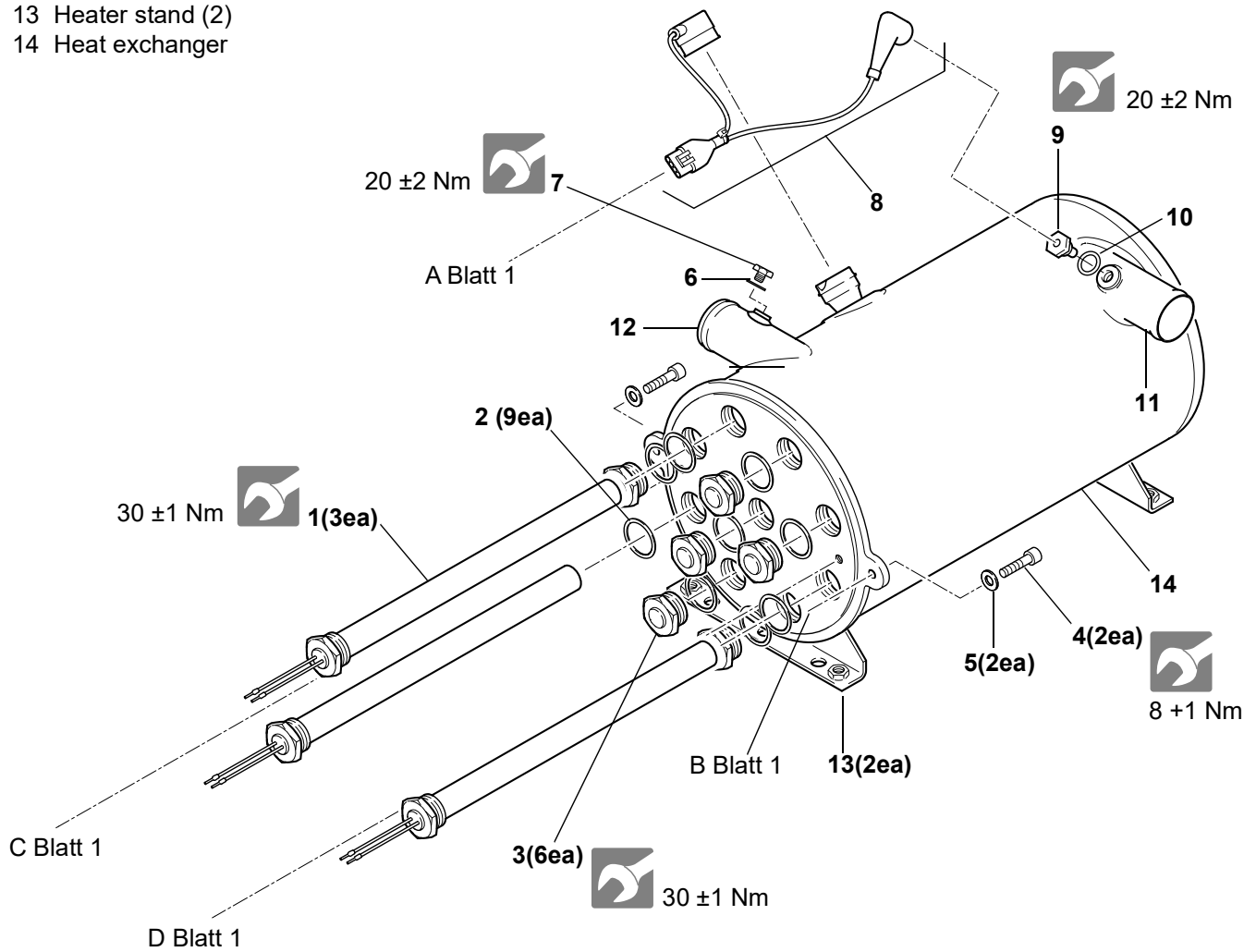
- 1 Hood
- 2 Hood screw (2)
- 3 Cable gland power supply
- 4 Cable gland control cables
- 5 Nut (2)
- 6 Washer (2)
- 7 Screw (2)
- 8 Stay bolts (2)
- 9 Gasket ring (2)
- 10 Adapter harness
- 11 PE Screw
- 12 Washer
- 13 Serrated washer
- 14 Small distribution board
- 15 Housing
- 16 Blind plug M20x1.5
- 17 Multilam plug
- 18 Socket
- 19 Nut
- 20 Serrated washer
- 21 Blind plug M16x1.5



NOTE:
The small distribution board (14) components differ depending on heater model.

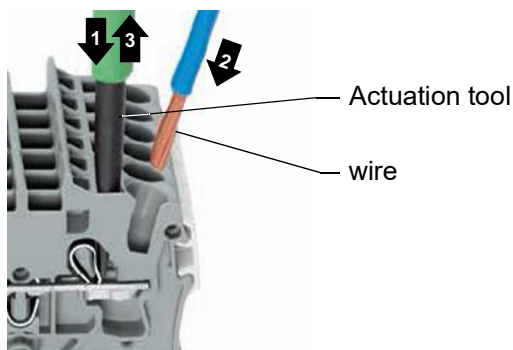
Fig. 803 (Sheet 1) Components removal/installation

- 1 Heating cartridges (3)*
- 2 Gasket ring (9)*
- 3 Screw plug (6)*
- 4 Screw (2)
- 5 Washer (2)
- 6 Gasket ring
- 7 Vent screw
- 8 Temperature guards
- 9 Screw-in socket
- 10 Gasket ring
- 11 Coolant outlet
- 12 Coolant inlet
- 13 Heater stand (2)
- 14 Heat exchanger



*) Number depends on heater model

Fig. 803 (Sheet 2) Components removal/installation



Connect wire: 1 - 2 - 3

Fig. 804

Removal

1. Establish voltage-free state of the heater and secure it for duration of the work (**Observe 1.6.3!**).
2. Remove housing (see 8.4).
3. Disconnect cable connections to heating cartridges.

NOTE:

For connections to be disconnected, refer to wiring diagrams in Chapter 6, Fig. 619 thru Fig. 626 depending on the heater version.

Compare the heater ident. number under the wiring diagram with that on the model plate of your heater.

4. If necessary remove the end clamps from the top hat rail.
5. Remove screws (8, Fig. 803, Sheet 1) and washers (9).
6. Remove small distribution board (16) from heater.

Installation

1. Position small distribution board (16, Fig. 803, Sheet 1) to the stay bolts (11) and secure using washers (9) and screws (8).
2. Ensure all electrical components are installed and aligned on the top hat rail.
3. If necessary install the end clamps to the top hat rail.
4. Hook-up heating cartridges to the WAGO® clamps.

NOTE:

For connections to be established, refer to wiring diagrams in Chapter 6, Fig. 619 thru Fig. 626 depending on the heater version.

Compare the heater ident. number under the wiring diagram with that on the model plate of your heater.

5. Install housing (see 8.4).
6. Install hood (see 8.3).

8.6 Heating cartridges/screw plugs removal/installation

Removal

1. Establish voltage-free state of the heater and secure it for duration of the work (**Observe 1.6.3!**)

NOTE:

To ensure the safe removal and installation of the heating cartridges, the heat exchanger is to be removed and placed in a vertical mounting position. To do this, the heater must be removed.

2. Remove heater (siehe 8.9).
3. Remove small distribution board (see 8.5).
4. Place heat exchanger into a vertical mounting position (see Fig. 805).

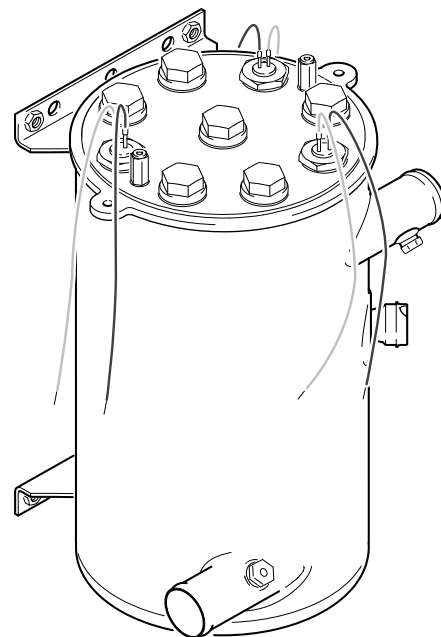


Fig. 805

5. Using a wrench loosen the heating cartridges (1, Fig. 803, Sheet 2) or the screw plugs (3), screw them out and remove them from heat exchanger. Discard gasket rings (2).

Installation

1. Remove remains of the heating cartridge sealing from the heat exchanger.
2. Preassemble heating cartridge (1, Fig. 803, Sheet 2) or screw plug (3) with a new gasket ring (2).

NOTE:

The groove of the gasket ring must in installed position rest on the heat exchanger.

3. Apply thread sealant according to the manufacturer's instructions onto the thread, see Fig. 806, of the heating cartridge (1, Fig. 803, Sheet 2) or the screw plug (3).

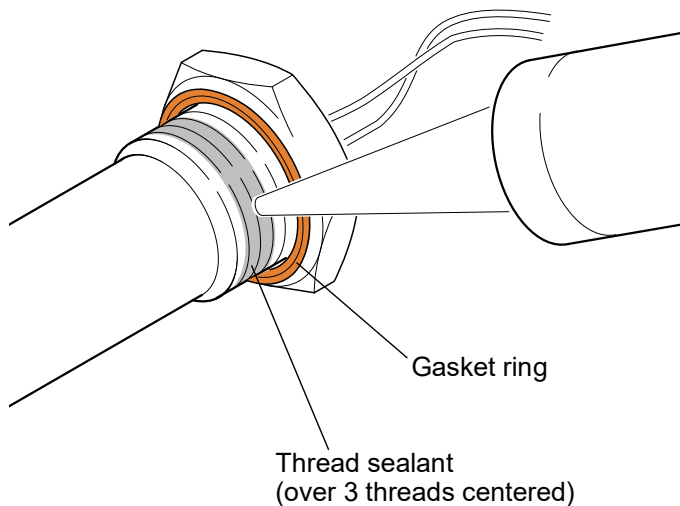


Fig. 806

4. Screw the heating cartridge (1) or the screw plug (3) into the heat exchanger.
5. Tighten the heating cartridge (1) or the screw plug (3) as required.
6. Install the small distribution board (see 8.5).
7. Install the heater (see 8.9).

8.7 HV wiring harness (AC/DC) removal/installation

Removal

1. Establish voltage-free state of the heater and secure it for duration of the work (**Observe 1.6.3!**)
2. Disconnect all supply cables from vehicle electrical system.
3. Remove housing (see 8.4).
4. Remove ties with bundle disconnected wires.

NOTE:

During the next step pay attention that the cables are not jammed or are still connected. "Danger of damage".

5. Loosen cable gland (4, Fig. 803, Sheet 1) and screw it with the appropriate cable harness from out the housing (17).

Installation

NOTE:

During the next step pay attention that the cables are not jammed. "Danger of damage".

1. Route the single wires of the HV wiring harness through the appropriate hole (see Fig. 803, Sheet 1) into the housing (17) and screw the cable gland (4) into the housing and tighten it.
2. Install housing (see 8.4).
3. Check the wiring again using the appropriate wiring diagram in Chapter 6.
4. Bundle single wires using cable ties.
5. Install hood (see 8.3).
6. Connect all supply cables to the vehicle electrical system, fix them if required.
7. Perform a function check.

8.8 LV DC control wiring harness removal/installation

Removal

1. Establish voltage-free state of the heater and secure it for duration of the work (**Observe 1.6.3!**)
2. Disconnect all supply cables from vehicle electrical system.
3. Remove housing (see 8.4).
4. If necessary disconnect connectors from the HVIL socket.
5. Remove ties with bundle disconnected wires.
6. Separate single wires at the end connectors and the small distribution board (see Fig. 601 thru Fig. 609 depending on the heater version).

NOTE:

During the next step pay attention that the cables are not jammed or are still connected. "Danger of damage".

7. Loosen cable gland (5, Fig. 803, Sheet 1) and screw it with the appropriate cable harness from out the housing (17).

Installation

NOTE:

During the next step pay attention that the cables are not jammed. "Danger of damage".

1. Route the single wires of the LV DC control wiring harness through the appropriate hole (see Fig. 803, Sheet 1) into the housing (17) and screw the cable gland (5) into the housing and tighten it.
2. Connect single wires as required with end connectors (see Fig. 601 thru Fig. 609 depending on the heater version).
3. Install housing (see 8.4).

4. If necessary reconnect connectors to the HVIL socket.
 5. Check the hook-up again using the wiring in Fig. 601 thru Fig. 609 depending on the heater version.
 6. Bundle single wires using cable ties.
 7. Install hood (see 8.3).
 8. Connect all supply cables to the vehicle electrical system, fix them if required.
 9. Perform a function check.
3. Unscrew grounding screw (15, Fig. 803, Sheet 1). Reinstall grounding screw with grounding cable and washer and tighten it.
 4. Feed the cables through the cable glands (4, 5) into the heater.
 5. Connect cables to the corresponding terminals of the small distribution board (16, Fig. 803, Sheet 1), tighten screws as prescribed.

8.9 Heater removal/installation



Risk of injuries if coolant temperature is increased.

Removal

1. Establish voltage-free state of the heater and secure it for duration of the work (**Observe 1.6.3 !**).
2. If installed, close water taps.
3. Close coolant inlet and outlet hoses using pinch off pliers.
4. Loosen hose clamps on the coolant hoses, pull coolant hoses from the coolant inlet (12, Fig. 803, Sheet 2) and outlet (11).
5. Remove hood (see 8.3).
6. Disconnect power supply and control cables by loosening the appropriate terminal screws from the small distribution board (16, Fig. 803, Sheet 1).
7. Loosen the cable glands (4, 5) and withdraw the cables.
8. Unscrew grounding screw (15) and remove grounding cable, reinstall grounding screw with washer.
9. Install hood (see 8.3).
10. Loosen and remove bolts, nuts and washers according to the attachment variant at the stand of the heat exchanger (13, Fig. 803, Sheet 2).
11. Remove heater from vehicle.

Installation

NOTE:

Initial situation: The heater is completely pre-assembled.

1. Remove hood (see 8.3).
2. Place heater in mounting position and secure with bolts, nuts and washers according to the mounting variant at the stand of the heat exchanger (13, Fig. 803, Sheet 2), tighten bolts.

NOTE:

For connections to be established, refer to wiring diagrams in Chapter 6, Fig. 601 thru Fig. 609 depending on the heater version.

Compare the heater ident. number under the wiring diagram with that on the model plate of your heater.

6. Check the wiring again using the appropriate wiring diagram in Chapter 6.
7. Bundle single wires using cable ties.
8. Tighten cable glands (4, 5) as specified.
9. Install hood (see 8.3).
10. Fit coolant hoses onto the coolant inlet (12, Fig. 803, Sheet 2) and the coolant outlet (11) and secure with hose clamps.
11. Remove pinch off pliers from coolant inlet and outlet hoses.
12. Restore power supply as required.
13. Bleed coolant circuit (see 8.11).

8.10 Heat exchanger removal/installation

1. Remove heating cartridges and screw plugs (see 8.6).
2. Remove temperature guards (see 8.2).
3. Unscrew stud bolts (11, Fig. 803, Sheet 1) and discard gasket rings (12).
4. Unscrew screw-in socket (9, Fig. 803, Sheet 2), discard gasket ring (10).
5. Unscrew screw plug (7), discard gasket (6).

Installation

1. Screw the screw plug (7, Fig. 803, Sheet 2) with a new gasket (6) in and tighten.
2. Screw the screw-in socket (9) with a new gasket (10) in and tighten.
3. Screw the stud bolts (11, Fig. 803, Sheet 1) with new gasket rings (12) in and tighten.
4. Install temperature guards (see 8.2).
5. Install heating cartridges and screw plugs (see 8.6).

8.11 Bleeding of the coolant circuit

NOTE:

The coolant circuit must be principally bled according to the manufacturer specification.



Risk of injuries if coolant temperature is increased.

The vent screw (7, [Fig. 803, Sheet 2](#)) can be used as an additional venting possibility.

Procedure

1. Pre-fill the heat exchanger and the water hoses fully with coolant.
2. Lightly loosen the vent screw.
3. Turn the circulating pump on.
4. As soon as no air escapes, close the vent screw and tighten (for torque value see [Fig. 803, Sheet 2](#)).

ATTENTION:

Existing air bubbles could lead to the destruction of the heating cartridges!

The correct degree of bleeding results in an almost silently operating circulation pump. An inadequate bleeding can lead during heating operation to the switching-off of the heater due to overheating.

9 Modifications and retrofits

9.1 General

For further optimization the heaters are continuously improved. Units in the field can usually be upgraded or retrofitted. For this purpose respective modification kits will be available.

10 Packing/storage/shipping

10.1 General

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

ATTENTION:

If a complete heater is sent back, it must be completely drained. While packaging and/or shipping it must be ensured that no coolant can leak.

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

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

Maintenance plan for heaters Thermo AC and Thermo DC

Periodic heater maintenance

The heater

- 1) should be operated for 10 minutes at least once a month and
- 2) checked by a professional according to the maintenance plan at the start of the heating season at the latest.

Observe the following maintenance intervals. These apply to normal applications of Spheros heaters.

The vehicle manufacturer's regulations and the relevant regulations of the Federal Railway Authority (EBA) and its technical service also apply.

The relevant workshop manual must be used to carry out the work. If the devices are used in other vehicles or applications, the intervals may be shortened or extended.

Please contact your responsible Spheros partner in such cases.



Installation, maintenance and repairs may only be carried out when the vehicle's engine is not running and the power supply is switched off.

Before starting the work at the heater, it is to make voltageless acc. to DIN VDE 0105-100 and this state must be ensured for the duration of the work.

In particular, the following safety precautions must be observed:

- switch off the power supply to the heater
- ensure it cannot be switched on again
- verify system is voltage-free, all poles
- ground and short circuit (the de-energized circuit)
- cover or block neighbouring parts under voltage

Electrical cables and operating elements of the heater must be arranged in the vehicle in such a way that their functioning is faultless under normal operating conditions and cannot be hampered.

Work at electrical equipment may only be started if protective measures against electric shock, short circuits and arcing faults have been carried out.

Work may only be performed by a qualified electrician for HV systems in motor vehicles, craftsman, activity with repetitive character. Training acc. to DGUV 200-005 (previously BGI 8686), at least level 2.

NOTE:

The provisions of these Regulations are binding within the territory governed by DGUV Regulations and should similarly be observed in countries without specific regulations. Country specific rules / standards are to be considered additionally.

Address of the operator	Date of Maintenance
	Vehicle data
Heater data	
Heater model:	Date of commissioning
Ident. no.:	
Serial no.:	

Maintenance plan for heaters Thermo AC and Thermo DC

Check / Maintenance	Interval	Results		Note	Measured values/ accomplished repairs
		OK	not OK		
During the maintenance, check all screw connections for tightness (for corresponding torque values see Workshop Manual).		<input type="checkbox"/>	<input type="checkbox"/>		
1. Electrics (connections, components) a) Examine electrical plug connections and the wiring harness for visible damages, replace as required. b) Verify the cables are secured properly with cable ties, if necessary, retrofit or replace them. c) Replace small distribution board only for version 11126153_	annually annually every 12 years every 5 years	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		
2. Heat exchanger Check for external damage, discoloration caused by overheating and leaks.	annually	<input type="checkbox"/>	<input type="checkbox"/>	Determine overheating cause as needed (e.g. lack of water); check overheat protection	
3. Temperature sensors a) Check temperature switch (water outlet) for function. b) Check temperature limiter for function. c) Replace temperature switch.	annually annually every 5 years	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		
4. Burner head a) Inspect hood for damage. b) Earth conductor check/check grounding resistance < 50mΩ against vehicle frame c) Check insulation resistance > 50 MΩ (at 1000V DC test voltage) d) Check insulation resistance between the HV contacts (A1 and A2) of the HV contactor: >50 MΩ (1000V DC test voltage) NOTE: HV cables on the contactor must be disconnected before measuring, then reconnected with 8 Nm+1 torque (for Thermo DC, H and H plus heaters only)	annually annually annually half-yearly	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Replace damaged parts.	
5. Warning notes a) Check warning labels.		<input type="checkbox"/>	<input type="checkbox"/>	Replace if absent or unrecognizable.	
6. Water system a) If available, inspect water filter insert.		<input type="checkbox"/>	<input type="checkbox"/>	Clean as needed or replace	
7. Functional check a) Check heater functionality. b) Check operation of circulating pump for 120s in purge cycle. c) Check ground fault interrupter (AC) or ISO guard (DC) for function (if necessary acc. to manufacturers instructions).	annually annually annually	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Check heat buildup after at least 10 min heater operation.	

