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# Repair manual

Liquid pre-heaters

14TC-Mini

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This repair manual (“RM”) is intended for use by the maintenance personnel servicing 14TC-Mini diesel engine pre-heaters (“pre-heaters”). This manual contains techniques for troubleshooting, as well as for determining whether various units and parts are in good condition or need to be replaced.

This manual also contains general technical specifications and descriptions of the units and their purpose as parts of the pre-heater, as well as tips for their maintenance and particular features of the various models.

The operating manual and the catalogue of parts and assemblies must be used alongside this manual during the repair of the pre-heater.

This repair manual may not include information about minor design alterations made by the manufacturer after the publication date of this RM.

Abbreviations used in the catalogue of parts and assemblies:

CU – control unit;

CP – control panel;

LPU – low-pressure unit;

FD – flame detector;

AB – air blower.

## 1 Main technical characteristics

See Table 1 for the main technical characteristics of the pre-heater.

The technical characteristics include a  $\pm 10\%$  tolerance and are specified for operation at the rated power supply voltage and air temperature of 20°C.

Table 1

<b>Rated power voltage, V</b>	<b>24</b>	<b>12</b>
Fuel type	diesel fuel in accordance with GOST 305, depending on ambient air temperature	
Heat transfer agent	antifreeze	
Heat capacity, kW:		
- in full-duty mode	14.5	14.5
- in medium-duty mode	9.2	9.2
- in low-duty mode	4.0	4.0
Fuel consumption, l/h:		
- in full-duty mode	1.9	1.9
- in medium-duty mode	1.2	1.2
- in low-duty mode	0.5	0.5
Power consumption, W, max.		
- in full-duty mode	113	124
- in medium-duty mode	100	95
- in low-duty mode	76	74
- in cooling mode	46	46
- within 90 seconds of startup	155	144
Ignition/shutdown mode	manual or automatic	
Mass, kg, max.	16	

## **2 Safety measures**

- 2.1. Relevant workforce safety rules must be observed during the repair.
- 2.2. Failure to observe pre-heater operation instructions may cause fire.
- 2.3. A workplace must be equipped with fire-fighting means.
- 2.4. Do not use the pre-heater with the cooling system empty.
- 2.5. Do not refuel an operating pre-heater.
- 2.6. Do not use the pre-heater within confined spaces and in poorly ventilated rooms.
- 2.7. Do not switch off power to the pre-heater before the purging cycle ends.
- 2.8. Do not connect and disconnect the terminals on the control panel and the control unit with the pre-heater switched on.

## **3 Construction and description of the main units of the pre-heater**

- 3.1 The construction, main units and parts of the pre-heater are shown in the CPA (catalogue of parts and assemblies).
- 3.2 The electric circuit diagram is shown in the operating manual.

## **4 Possible pre-heater faults, their root causes, and troubleshooting methods**

A fault may occur during operation of the pre-heater. A corresponding malfunction code is displayed on PU-11M control panel. Malfunction codes and troubleshooting methods are described in Table 2.

There may be faults that are not identifiable via the control unit, such as loss of sealing in the heat exchanger (burning out), burning out of seal gaskets, loss of heat capacity due to fouling of the inner surface of the heat exchanger, or fuel pump filter clogging. The above faults may be diagnosed by visual inspection.

**DO NOT OPERATE THE PRE-HEATER WITH A POORLY SEALED HEAT EXCHANGER.**

During pre-heater operation, some of its units may fail to operate and can be replaced without removing the entire pre-heater from the vehicle. Such units include the control unit, the pump, the plugs, the control panel, or the fuel pump.

Table 2

<b>Malfunction code</b>	<b>Malfunction description</b>	<b>Cause of malfunction</b>	<b>Recommended troubleshooting methods</b>
<b>01</b>	Overheating	The overheating sensor or the temperature sensor indicates temperature above 102°C	Check the entire liquid circuit for air blocks. Check the pump (section 5.7). Check sensors (section 5.2)
<b>02</b>	Possible overheating is indicated	Heating rate is too high	
<b>03</b>	Overheating sensor fault	Short or open circuit, control unit fault	Check wires and connections. Check the sensor (section 5.2)
<b>04</b>	Temperature sensor fault		
<b>05</b>	Flame detector fault	Short circuit to frame or open circuit. Control unit fault	Check the flame detector (section 5.3)
<b>06</b>	Built-in temperature sensor fault	The temperature sensor is faulty (located in the control unit)	Replace the control unit (section 5.10)
<b>09</b>	Glow plug fault	Short or open circuit	Check the glow plug (section 5.1)
<b>10</b>	Air blower fault (obstructed rotation)	Excessive friction inside bearings, or the spinner hitting the scroll	Check the air blower (section 5.4)
<b>27</b>	Air blower fault (the motor does not rotate)	Oxidation of terminal block contacts. Jamming due to destruction of the bearing or the rotor. Foreign objects have fallen into the unit etc.	
<b>28</b>	Air blower fault (the motor rotates at a constant speed)	Malfunction of the electric motor control board or the control unit	

Table 2

Malfunction code	Malfunction description	Cause of malfunction	Recommended troubleshooting methods
12	Shutdown due to overvoltage (above 16/30 V)	Voltage regulator fault. Battery fault	Check battery terminals and adjacent wiring. Check the battery, recharge or replace if necessary. Check operation of the vehicle voltage regulator
15	Shutdown due to undervoltage (below 10.5/20 V)		
13	All attempts to start failed. Failure to ignite (after two attempts).	No fuel	Check presence of fuel. Check the fuel pump. Check the air intake and the exhaust pipe. Check the glow plug (section 5.1). Check the combustion chamber (section 5.5)
		Insufficient fuel supply	
		The gas exhaust pipeline or the air intake is clogged	
		Insufficient heating of the plug, control unit fault	
		The 1.5 mm opening in the combustion chamber plug socket is clogged	
14	Pump fault	Short or open circuit	Check the wiring and the terminal block. Check the pump (section 5.7)
16	Flame detector is not cool enough	The pre-heater has not been cooled down sufficiently by purging	Check the air intake and the exhaust pipe. Check the flame detector
17	Fuel pump fault	Short or open circuit in fuel pump wiring	Check fuel pump wiring for short or open circuit. Check if the insulation of wiring leading to the overheating sensor is intact
20	No communication between the control panel and the pre-heater	Short or open circuit in the wiring	Check connecting wires and the connector
29	Allowable flame blowoff number during operation is exceeded		Check the amount and flow of fuel supplied. Check the combustion air supply system and the gas exhaust pipeline. If the pre-heater starts, check the fuel pump and replace if necessary
78	Flame blowoff during operation		Check the air intake, the gas exhaust pipeline, and fuel supply, resolve the faults and replace the fuel pump and the flame detector if necessary

## 5 Purpose, repair, and replacement of pre-heater units

The main units of the heater are shown in the CPA (catalogue of parts and assemblies). Partial disassembly of the heater is required to check the condition of heater units or to replace them. **Partial disassembly of the heater may be performed without dismounting the heater from the vehicle, provided dismounting of the control unit is possible.**

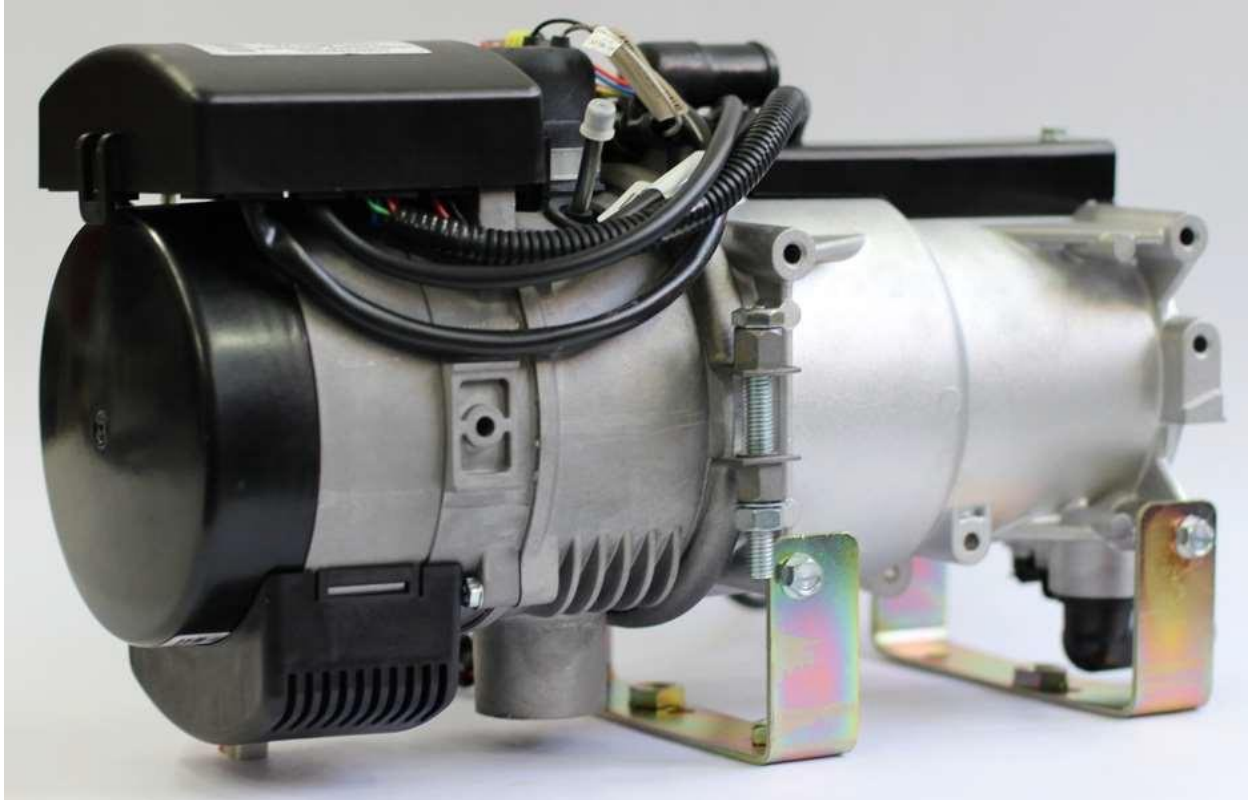


Fig. 1. Heater unit (top view)

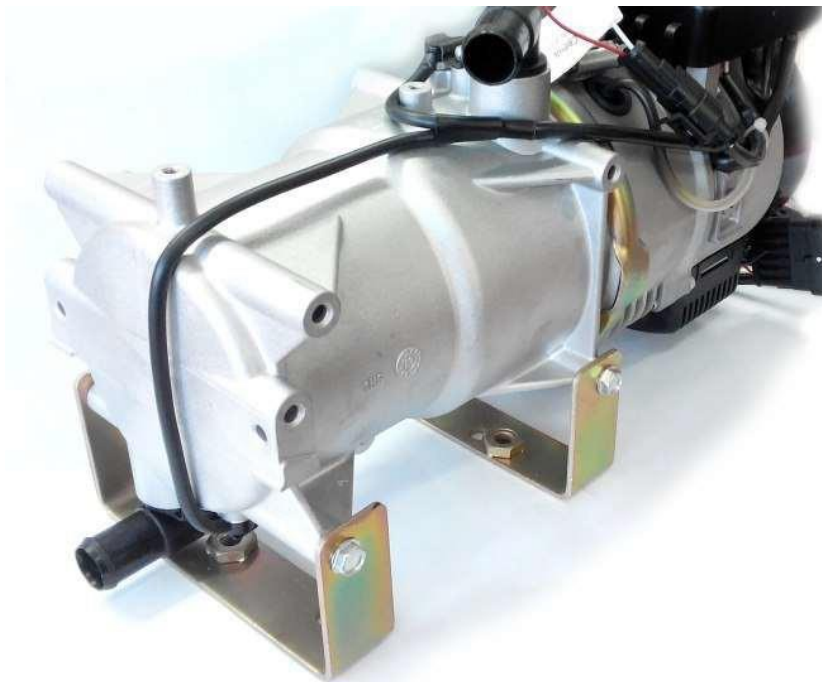


Fig. 1a. Heater unit (side view, with sensor cover removed)



### 5.1 Purpose, dismounting, and replacement of the glow plug

The glow plug (Fig. 2) ensures ignition of air-gas mixture as the pre-heater starts. To check the operation of the plug and replace the plug:

- cut off fuel supply to the pre-heater (disconnect the fuel line from the heater, and put the loose end of the line in a suitable vessel),
- disconnect the plug connector,
- loose the clamp and remove the rubber cap from the plug,
- unscrew the plug,
- reconnect the plug connector, and turn the pre-heater on. Note whether the plug is being heated from its end and up to about the middle of the heating element. If the element starts heating up from the middle or heats all the way to the bottom, the plug is faulty.

If the plug heats up poorly, check the control unit. Replace the CU with a good one. If the pre-heater works fine after this replacement, the CU removed may be deemed faulty.

If the plug does not heat up, check its operation. To do that, disconnect the plug connector, and connect the plug to a 9/18 V (depending on a plug) direct current source, wait 30 s, and measure the current consumed. Note how the plug heats up.

The consumed current must be within 5.2–6.78 A (for a **9V** plug) or 2.5–3.4 A (for an **18V** plug). Continue the test for no more than 90 s. Wait no less than 180 s before repeating the test.

If the plug does not meet at least one of the above requirements, replace it. Replace the plug in the reverse order.

During plug replacement, replace the plug washer (Fig. 2) as well.

If the plug works fine, check the wires and contacts on the plug connector. If the contacts are clean, replace the plug, and try to startup the pre-heater. If the pre-heater does not launch with a new plug either, replace the CU with a good one, and try to launch the pre-heater again. If the pre-heater works fine after the CU replacement, the removed CU may be deemed faulty.

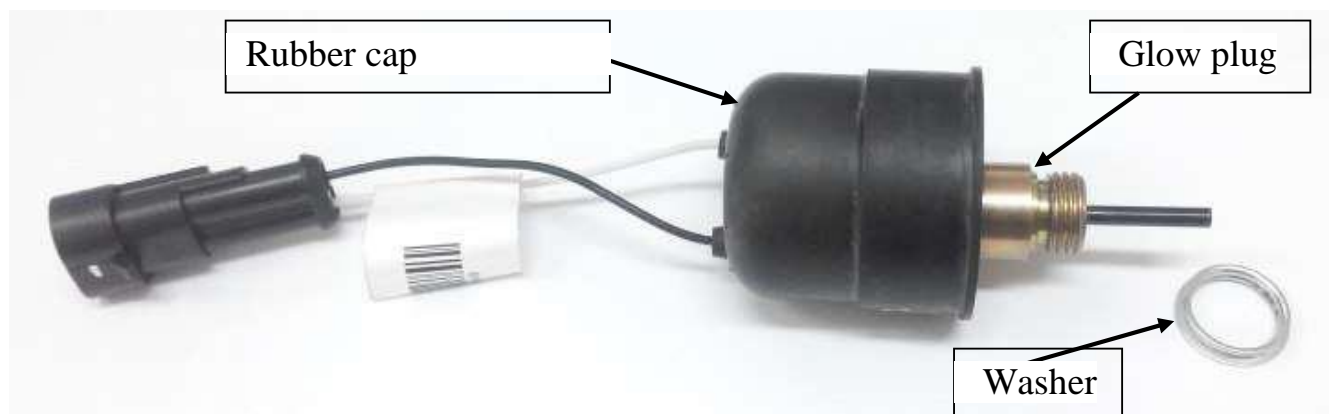


Fig. 2. Glow plug

## 5.2 Purpose, dismounting, and replacement of the temperature and overheating sensors

The temperature and overheating sensors are installed within one assembly (Fig. 3). The sensors monitor the temperatures of heated liquid and the heat exchanger. Both sensors are identical chips mounted in a metal case.



Fig. 3. Sensor assembly

Sensors on pre-heaters manufactured before May 2016 are located as shown in Fig. 1a and Fig. 4.



Fig. 4. Location of sensors

In May 2016, the overheating sensor was moved from the lower to the upper side of the case, and a seal is installed to cover the old sensor seat on the lower side (Fig. 4a).

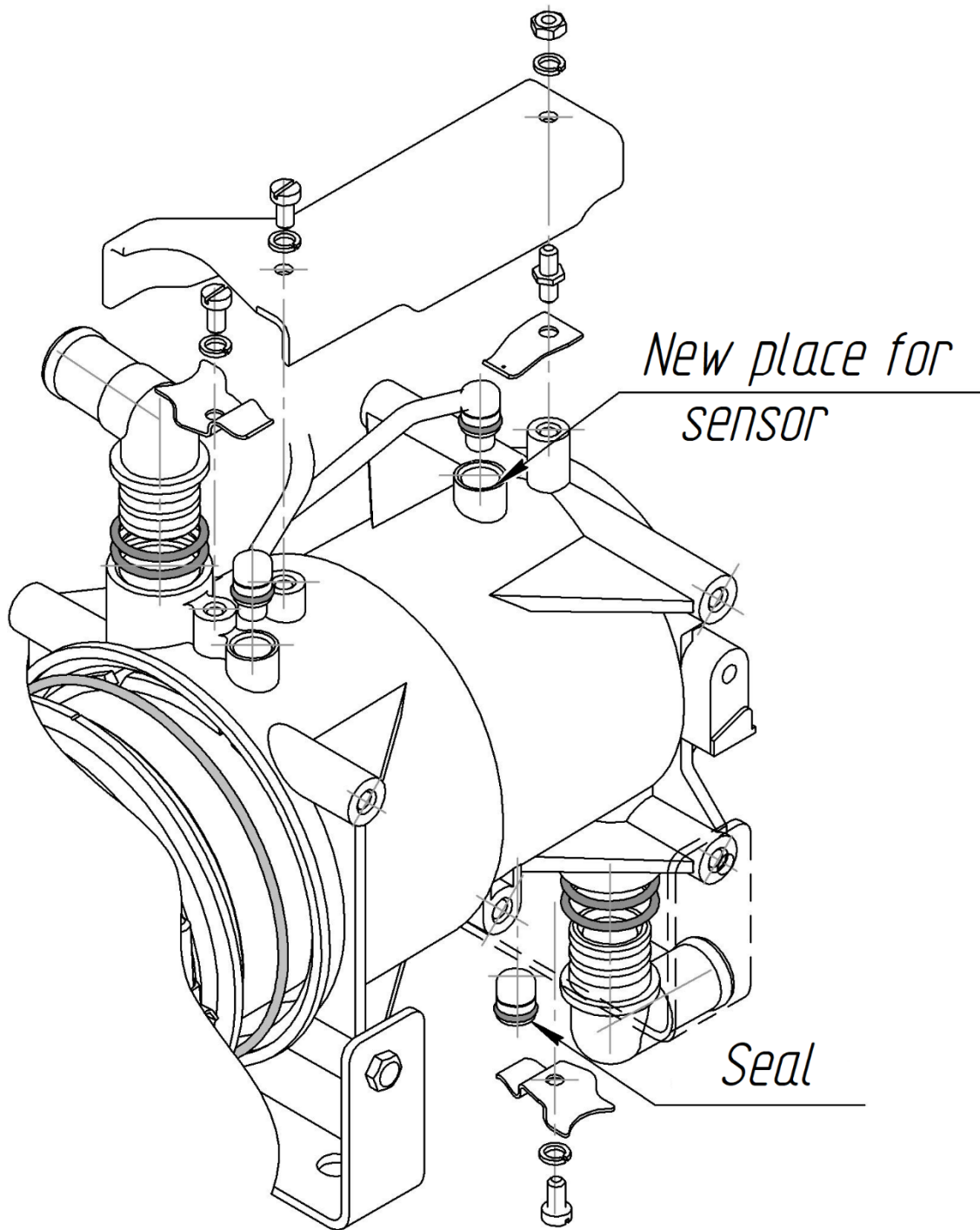


Fig. 4a. Location of sensors

Depending on readings of the temperature sensors, the control unit switches the pre- heater off if one of the following conditions is met:

- any sensor indicates temperature above 102°C,
- the heating rate is too high (over 10° a second).

If failures are caused by the sensors and not by quality of coolant or the pump, check the sensors.

To check the sensors, partially disassemble the heater first. Remove the control unit cover and check the output voltage of the sensors. At 0°C, the output voltage is 2.73 V. At higher temperatures, the output voltage is also higher: every 1°C increase in temperature corresponds to 0.01 V increase at the sensor output.

It is recommended that you measure the voltage with the coolant at ambient temperature.

Compare the sensor readings with the actual liquid temperature. In case of short circuit, or if the readings from a sensor do not match actual coolant temperature, this sensor must be deemed faulty and should be replaced.

To dismount and replace a sensor:

- cut off the fuel supply to the pre-heater,
- switch off power to the pre-heater,
- drain the coolant from the vehicle system\*,
- open the latches, and remove the cover from the control unit,
- loosen the terminal screws and disconnect the wire connectors from terminals,
- remove the screws fastening the sensor cover,
- remove the screw, remove the holddown from one sensor, remove it from the heater case, and replace with a new one. Do the same with the second sensor.

Replace the sensor assembly in the reverse order. Connect the wire with a black mark (or the black wire) to the connector with a black dot above it. After installing the sensors, refill the antifreeze and remove air from the liquid circuit of the vehicle following the vehicle manufacturer's instructions.

\* If draining the liquid is impossible for sensor replacement, pinch the pipes with C- clamps, and plug the sensor opening with a finger.

**Attention! Use this method only after ensuring the vehicle engine is off and the liquid temperature is not above 40°C!**

### 5.3 Purpose, dismounting, and replacement of the flame detector

The flame detector (Fig. 5) is used to detect flame in the combustion chamber. It is comprised of a pipe with a thermocouple with two outputs inside.



Fig. 5. Flame detector

Check the flame detector if malfunction codes 05 and 16 (as per Table 2) are displayed.

If the fault appears during the pre-heater startup:

- cut off the fuel supply to the pre-heater,
- shut off power to the pre-heater (disconnect the main connector),
- open the latches, and remove the cover from the control unit,
- loosen the flame detector terminal screws, and disconnect the wire connectors from terminals.

Check the resistance. The FD should indicate a short circuit or resistance no higher than 5  $\Omega$ . If the FD indicates an open circuit, it is faulty and must be replaced.

Check the FD channel on the control unit. Install a jumper in place of the FD (Fig. 5a). Start up the pre-heater. If a malfunction code related to the FD does not appear after the pre-heater launch, the CU is fault-free. Turn the pre-heater off, and remove the jumper.

Further troubleshooting involves heater disassembly. To do so:

- remove the screws fastening the air blower to the adapter (if it is impossible to remove the air blower, drain the coolant, and remove the heater from the vehicle),
- remove the nut fastening the FD to the adapter, and remove the FD.

Check the insulation resistance between the outputs and the FD case. It must not be lower than 100 M $\Omega$  at 100 V. Measure the resistance at 15–35°C and relative humidity not above 80%. If the insulation resistance does not meet this criterion, replace the FD.



If an error appears during the pre-heater operation, either there is a crack in the weld of the FD thermocouple (i.e. the circuit is open), or the polarity of the FD connection is reversed. The fault may be revealed using two methods:

- 1) Remove the FD from the heat exchanger case (Fig. 6), connect the terminals of the FD to a multimeter (at the temperature measuring terminals), and heat up the FD, for instance, with a lighter. The temperature must increase gradually. If it increases in surges or goes down to the initial value, the FD is damaged. In this case, however, the circuit may close after the FD has cooled down.
- 2) Remove the FD from the heat exchanger case, and measure the voltage at outputs of the FD that is being heated up. When the FD case is heated up to  $+100^{\circ}\text{C}$  (boiling water temperature), its outputs must provide voltage at about 3 mV. The positive pole is marked with a red tube, and the negative pole is marked with a black tube.

In case of an open circuit, the FD must be deemed faulty and should be replaced.

To check if the FD is really faulty, replace it with a good one. If the new FD does not cause the same fault, the replaced one must be deemed faulty.

Replace the FD in the reverse order.

Where the fault persists, check the polarity of the FD connection (the wire with a black mark must be connected with the CU connector marked with a black dot, as shown in Fig. 6a). An error in the placement of the marking on the FD wires is also possible. Check the correctness of the wire markings with a magnet. The terminal of the wire marked black must be magnetised.



Fig. 6. Jumper



Fig. 6a. FD to CU connection

#### *5.4 Purpose, dismantling, and replacement of the air blower*

The air blower (Fig. 7) supplies air to the combustion chamber, which is necessary for combustion in every operation mode. The air flow supplied to the combustion chamber is measured by the rotation speed of a spinner inside the air blower. The rotation speed is registered by a PWM signal sent from the control unit according to a programme. The air blower is also used for purging the combustion chamber before and after the combustion process to cool down the chamber, dehumidify it, and remove residual fuel.

The air blower must be replaced in case of a fault in the electric motor or the spinner (this may be detected by a change of noise and low air flow).

If the air blower does not rotate, check its operation. Connect the blue wire terminal to the black wire terminal for a short time, as shown in Fig. 8. The AB must gradually speed up and just as gradually slow down as soon as the terminals are disconnected.

Dismount the air blower in the following order:

- cut off the fuel supply to the pre-heater,
- shut off power to the pre-heater (disconnect the main connector),
- dismount the CU cover, and disconnect the AB terminals from their connectors,
- remove the screws fastening the CU to the air blower,
- remove the screws fastening the AB to the adapter, then disconnect the AB from the adapter.

Mount the air blower in the reverse order.

**Attention! The air blower must be replaced completely with a new one!**

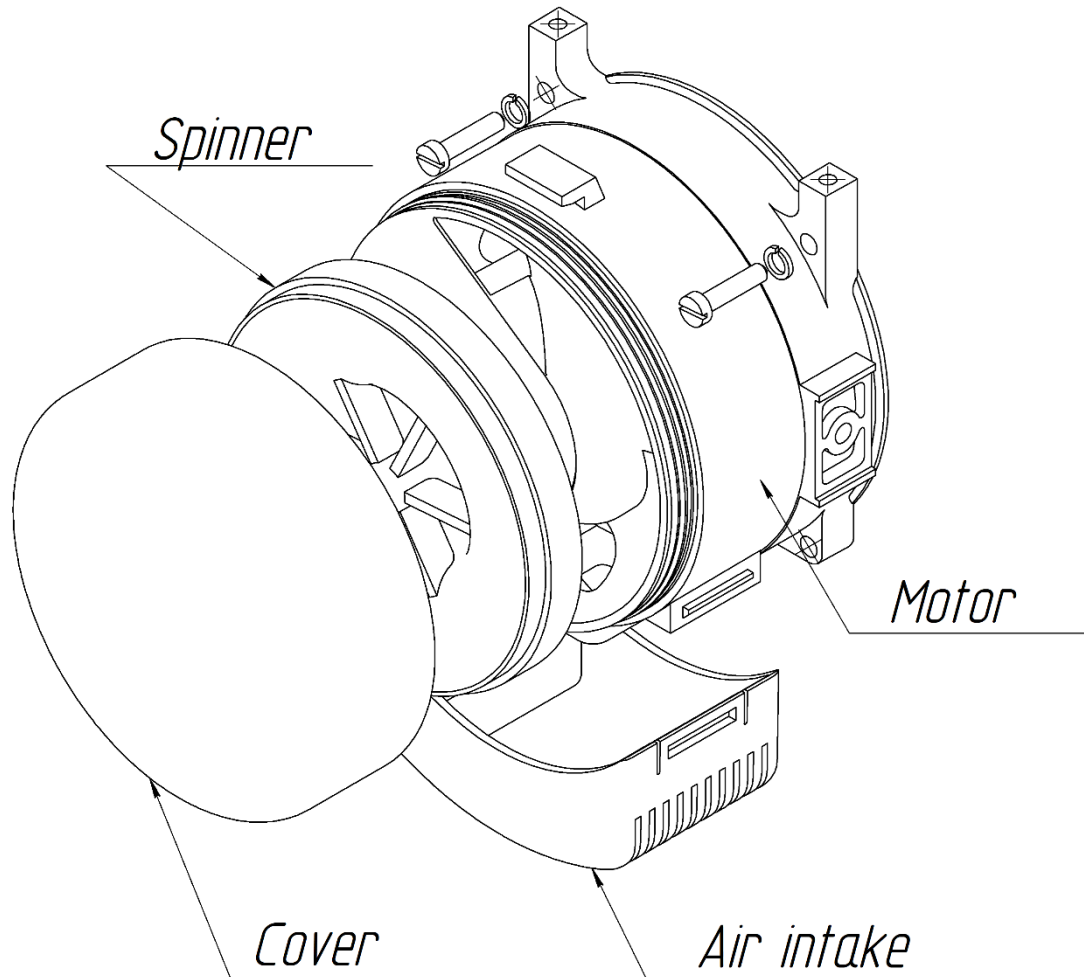


Fig. 7. Air blower

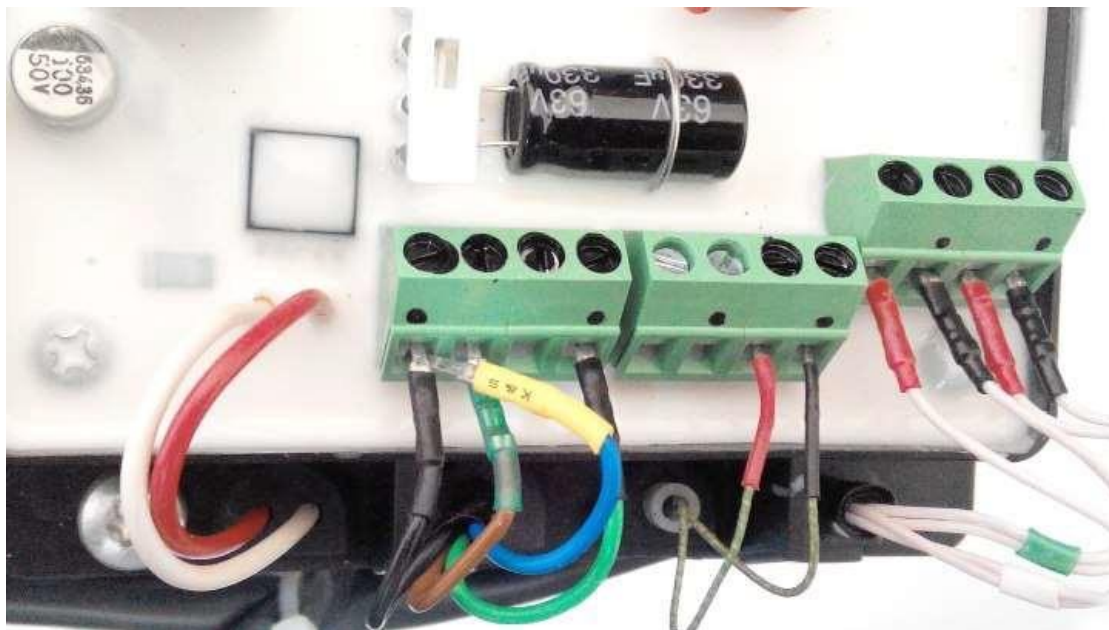


Fig. 8. AB operation check



### 5.5 Purpose, dismounting, and replacement of the combustion chamber

The combustion chamber (Fig. 9) is used for creating and burning the air-fuel mixture. Symptoms of combustion chamber faults are:

- a failure to start the pre-heater (provided other parts are fault-free), a burnt-out case or inner parts of the chamber,
- a high (above 500°C) temperature of the exhaust gases,
- low heat capacity.

Visually inspect the combustion chamber. To do so, first partially disassemble the heater in the following order:

- cut off the fuel supply to the pre-heater,
- switch off power to the pre-heater,
- drain the coolant from the vehicle system,
- remove the heater from the vehicle,
- unscrew the plug,
- unmount the air blower,
- unmount the flame detector,
- remove the nuts and the swirler,
- remove the screw of the fastening clamp (Fig. 1), and disconnect the adapter from the pre-heater case.

Where visual inspection reveals burnt-out parts or spots on the case, replace the combustion chamber.

Install the combustion chamber in the reverse order with a new gasket between the combustion chamber and the adapter (see CPA). Visually inspect the heat exchanger as described in section 5.6 as well.



Fig. 9. Combustion chamber

### 5.6 Purpose, dismounting, and replacement of the heat exchanger

The heat exchanger (Fig. 10) is used to transfer heat from the hot gas flow generated as a result of combustion of the air-fuel mixture to the coolant circulating in the liquid jacket of the heater.

One fault that may appear during heat exchanger operation is loss of seal. Its symptoms are grumbling or explosive noises of burning caused by the entry of coolant into the gas-air line.

Dismount the heat exchanger in the following order:

- cut off the fuel supply to the pre-heater,
- switch off power to the pre-heater,
- drain the coolant from the vehicle system or use C-clamps,
- remove the heater from the vehicle,
- remove the cover from the control unit, and disconnect the terminals of the temperature sensors,
- remove the screw of the fastening clamp (Fig. 1), and disconnect the combustion chamber together with the adapter and the air blower from the pre-heater case,
- remove the heat exchanger from the heater case.

Install the heat exchanger after cleaning or replacement in the reverse order. Make sure to visually inspect the O-ring (see CPA) located between the heat exchanger and the case. Replace the O-ring where any tears, scratches, or deformations are found.

Before installing the heat exchanger, loosen the sensor holddown (Fig. 5). Make sure to install the heat exchanger in the correct orientation. One of the inner fins of the heat exchanger is shorter than others. This fin must be located against the flame detector.

After installing the heat exchanger and tightening the clamp, fasten the sensor holddowns, and check the seal of the heater liquid circuit with compressed air at 0.25 MPa (2.5 kgf/cm<sup>2</sup>). Supply compressed air for five minutes. No air pressure drop must be observed.



Fig. 10. Heat exchanger

### 5.7 Purpose, dismounting, and replacement of the electric motor and the pump

The electric motor and the pump (Fig. 11) are used to circulate coolant across the vehicle engine/cabin heating systems.

The pump may fail to operate for the following reasons:

- poor coolant quality (frozen coolant),
- foreign particles inside the liquid circuit,
- short or open circuit in the electric wiring,
- wear on the working parts of the pump,
- antifreeze leakage.

**Attention!** If an antifreeze leak is found, replace the pump! Do not use the pre-heater with a poorly sealed pump.

If the coolant is frozen (has turned into a snow-like mass) inside the pump, the pump will continue to operate but will not be able to circulate any coolant. Unfreeze the pump, and replace the coolant with that of better quality.

Where there are foreign particles (such as fine chippings or sawdust) inside the liquid circuit, they may obstruct pump operation. A clear symptom of a contaminated pump is poor circulation of the coolant. To clean the pump, partially disassemble it in the following order:

- remove the pump from the vehicle (drain the coolant, or use C-clamps, as necessary),
- remove the four screws, and remove the cover,
- clean the cover and the spinner of foreign particles,
- reinstall the cover, and check the pump operation.

If the pump does not turn on, check the wiring. If the wiring is not visibly damaged, connect an electric source at the pump operating voltage directly to the pump terminals for a short period. If the pump starts, it is fault-free. Check the wiring with a multimeter.



Fig. 11. Electric motor and the pump

### 5.8 Purpose, dismantling, and replacement of the control unit

The control unit (Fig. 12) is installed onto the air blower and is used for automatic control of the pre-heater operation. It also provides diagnostics and monitoring of pre- heater units during operation.

During troubleshooting of the control unit, first ensure all parts of the pre-heater are in working order, and then check the fuse. If the fuse is fault-free as well, replace the control unit. If the pre-heater with a new control unit works fine, the one removed must be deemed faulty and should be replaced.

To dismantle the control unit:

- switch off power to the pre-heater,
- open the latches, and remove the cover from the control unit,
- disconnect all connectors,
- disconnect the wires for the sensors, FD, and AB from the control unit connectors,
- remove the screws from the CU case, dismantle the CU. Reinstall the control unit in the reverse order.

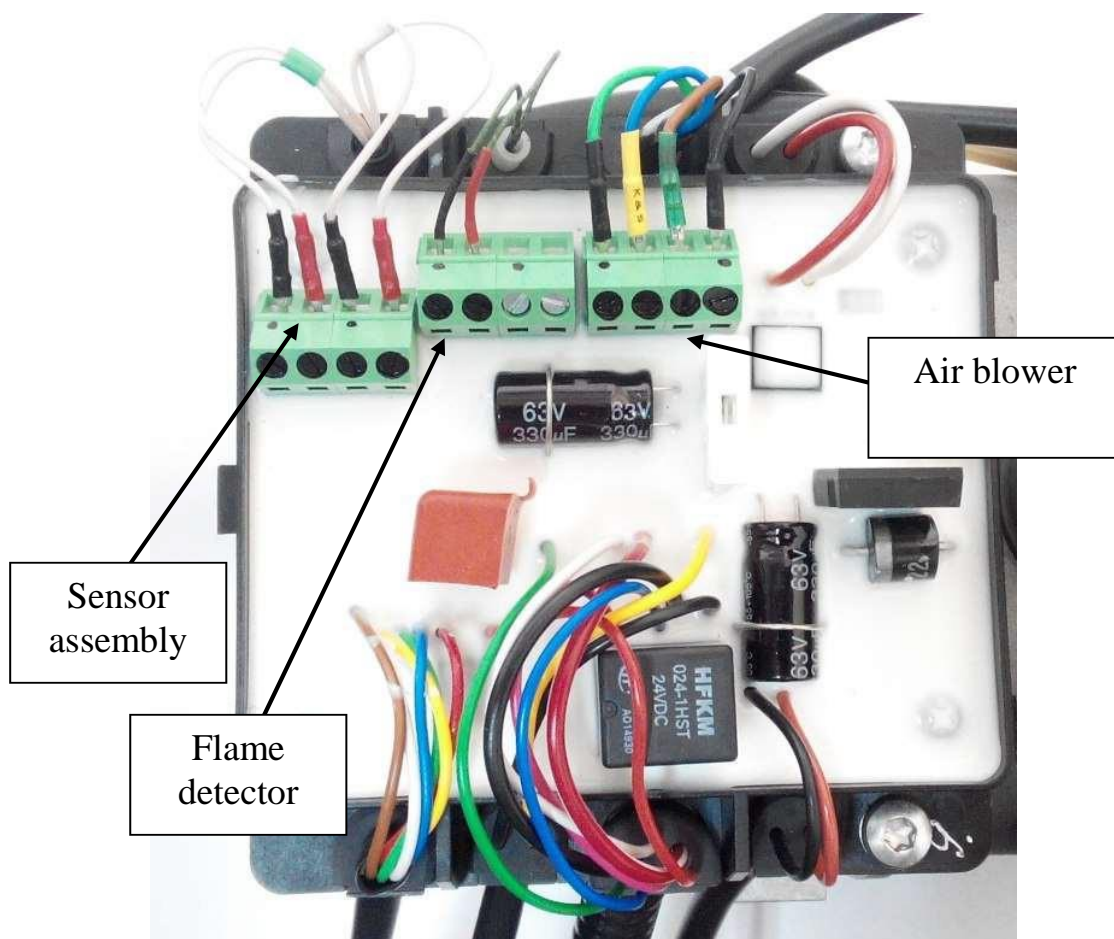


Fig. 12. Control unit

### 5.9 Purpose, dismantling, and replacement of the control panel

The control panel (Fig. 13, “panel”) provides manual control of the pre-heater, including:

- manual startup and shutdown of the pre-heater,
- setting the pre-heater operation duration (3 or 8 hours),
- indication of the pre-heater status (on/off/fault).

To check whether the control panel is faulty, check the wire terminal blocks.

If the check does not reveal any faults, but the control panel still does not operate, replace the control panel with a new one. If the new control panel does not cause the same fault, the replaced one must be deemed faulty.

To dismantle the control panel:

- disconnect the panel connector from the harness connector,
- remove the panel from its mounting bracket.

Reinstall the control panel in the reverse order. If the panel is fault-free, but the pre-heater still fails to start, check the wiring in the harness and the CU.



Fig. 13. Control panel

### *5.10 Purpose, dismantling, and replacement of the fuel pump*

The fuel pump (Fig. 11) is used for metered fuel supply to the combustion chamber.

Main characteristics of the fuel pump:

- the rated supply voltage is 12 or 24 V,
- coil resistance:
  - a) 2.5–3  $\Omega$  (for a 12 V fuel pump),
  - b) 14.5–16  $\Omega$  (for a 24 V fuel pump),
- the fuel pump capacity specified on the label is for 100 cycles.

Possible fuel pump faults:

- a) fuel is not supplied to the fuel pipe of the heater during launch, and a characteristic knocking noise from the fuel pump is absent,
- b) the fuel pump operates (the characteristic knocking noise is heard), but no fuel is supplied to the fuel pipe of the pre-heater,
- c) combustion stops when the pre-heater is switched to the “max.” operation mode, which means the fuel pump does not provide the required capacity.

To repair faults and determine the capacity of the fuel pump:

- before troubleshooting, first check the presence and quality of fuel in the tank,
- check the condition of the wiring and connectors,
- check whether the fuel pump launches during the pre-heater startup and emits the characteristic noise of the piston moving inside the pump.

You may dismantle the fuel pump and shake it to release the piston jammed inside the pump after long storage or failure to observe the preventive maintenance specified in the operating manual.

To check the pump operation, you may connect a power source at the rated voltage of the pump to the pump terminals for a short time (emulating impulses). If the characteristic knocking noise is heard, the fuel pump is fault-free.

- Check the seal of the fuel line over its entire length to the fuel pump and from the fuel pump to the heater.
- Check whether the filter is clean. Remove the inlet nozzle of the fuel pump, and visually inspect the filter. Flush it with petrol and purge with compressed air if necessary.



If all of the above faults are repaired, check the capacity of the fuel pump. The fuel pump capacity must correspond to the value specified on the label (with a  $\pm 10\%$  tolerance) per 100 cycles. If the capacity is below or above that specified, replace the fuel pump.

To dismount and reinstall the fuel pump:

- loosen the clamps and disconnect the fuel lines from fuel pump nozzles,
- disconnect the wiring from the fuel pump,
- remove the fuel pump from the clamp. Reinstall the fuel pump in the reverse order.

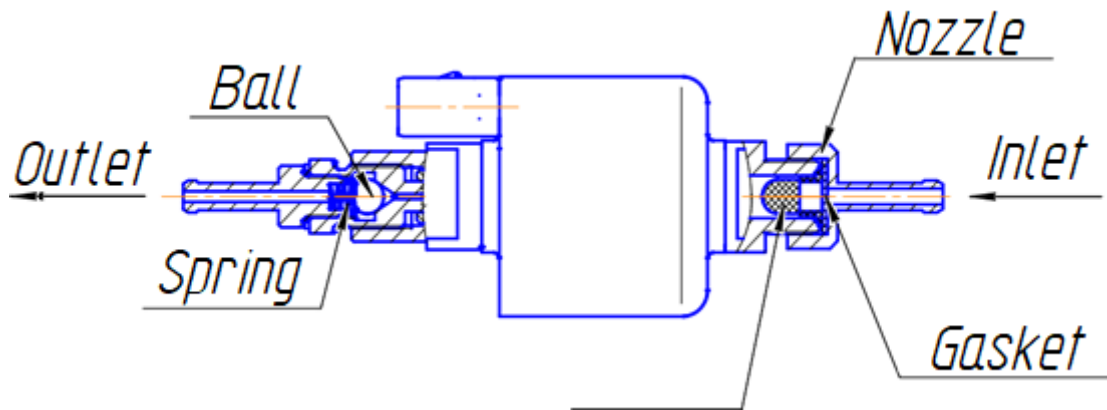


Fig. 14. Fuel pump

## 6 Process equipment for maintenance

### 6.1. Test bench

Maintenance of pre-heaters may be performed on a stationary control bench manufactured by Advers OOO.

The bench allows you to:

- a) test the pre-heater and the heater using a diagnostic device and reveal faults,
- b) check operation of the fuel pump, the air blower, the temperature and overheating sensors, the flame detector, and the glow plug,
- c) check the operation of the pre-heater and the heater after repair.

The main characteristics and guidelines for using the bench are specified in the operating manual for a DV 1105.000 bench.



Fig. 13. Pre-heater test bench

**Note:** use of this bench allows quick and quality maintenance of pre-heaters and heaters.

### 6.2. USB adapter

The USB adapter is used to connect hydronic pre-heaters and air heaters to a PC. The adapter is connected in place of the control panel and allows diagnosis of the pre-heater using proprietary software.

For more details, see the operating manual for the USB adapter.