

THERMAL DESORBER TDS-1

(TWO STAGE)

USER MANUAL

214.2.393.004-02UM

PRODUCT P/N: 400-1101

Rev. 27.12.2023

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Important notes

The present user manual covers Thermal Desorber TDS-1 (further – the thermal desorber) and contains all instructions needed to ensure proper system operation.

Before working with thermal desorber, accurately read the present user manual and associated manuals for GC that will be used together with thermal desorber.

These guide specifications and describes the operating principle apply to thermal desorber issued after 2012 (serial number above 210206).

The corresponding user manual sections contain specific guidelines that should be followed during thermal desorber service and maintenance.

Notes marked with this symbol should be followed to prevent injury when operating the thermal desorber.



Follow the instruction marked with such symbol to prevent burns when touching the heated surface.



Follow the instruction marked with this symbol to prevent the explosion hazard.

Two marking types of parts are used in this and accompanied documents:

XXX-XXXX – *Part number* or *Cat. Number* referred to ordering documents;

214.X.XXX.XXX(-XX) or simplified X.XXX.XXX(-XX) – *Cross ID* referred to internal manufacturer documents.

Both can be used for ordering parts.

1 Description

1.1 Introduction

The Thermal desorber (P/N 400-1101) is intended for thermal desorption of volatile compounds that are pre-concentrated in sample tubes packed with sorbents. With additional concentration of sample in cold trap, you can focus it before sample goes into chromatographic column.

The thermal desorber may be used in explosion-proof and fire-protected laboratory rooms with ambient temperature between 10 and 35 °C, relative humidity up to 80 %, ambient pressure between 84 and 107 kPa (630 to 800 mm Hg), air contaminants within acceptable limits specified by hygiene standard GOST 12.1.005-88. For environmental design, thermal desorber refers to UHL cat. 4.2 per standard GOST 15150-69.

The thermal desorber operates from 187 – 242 VAC (50±1) Hz mains.

1.2 Technical specifications

Sample tube size (O.D., length), mm	– 6; 115.
Minimum sorbent volume in sample tube, ml	– 0,85.
Sample tube temperature, °C	– (tamb*+10) to 400.
Cold trap temperature, °C	– minus 20 to 400.
Valve temperature, °C	– 150 to 250.
Transfer line temperature, °C	– 40 to 250.
Carrier gas flow rate, ml/min	– 0 to 200.
Purge gas flow rate, ml/min	– 0 to 200.
Relative standard deviation (RSD) of output signal (heights, areas and retention times) when using thermal desorber, %, max.	– 2.
Dimensions (width, depth, height), mm, max.	– 280, 480, 550.
Weight, kg, max.	– 20.
Power consumption, W, max.	– 700.

* t_{amb} – ambient temperature

1.3 Delivery set

The thermal desorber contains the items and documents listed in the Passport.

1.4 Construction

Items produced by SDO Chromatec may contain updated parts following new developments or may be undergone to non-essential modernization, not specified in this user manual.

The thermal desorber overview is shown in Figures below.

The thermal desorber configuration includes the following functional units:

- sample tube oven;
- cold trap;
- heated switching valve controlled by electric drive;
- heated transfer line;
- flow regulators;
- solenoid valves;
- power supply;
- controller;
- keyboard;
- display.

The Figure 1.1 shows a general view of the thermal desorber.

The thermal desorber comprises of two parts: analytical section (under top cover) and electronic section (under right cover). The analytical section of thermal desorber incorporates a sample tube oven, cold trap and switching valve. The electronic section includes gas regulators, solenoid valves, controller and power supply.

The front panel features keyboard and display.

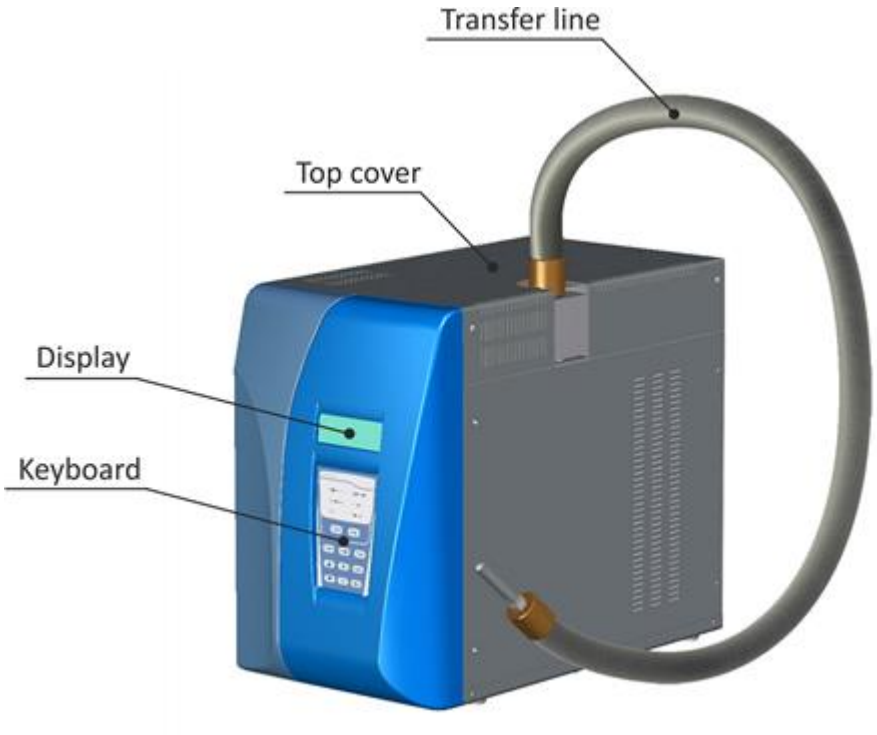


Figure 1.1 – Thermal desorber, P/N 400-1101. General view

The Figure 1.2 shows a rear view of the thermal desorber.

The rear panel incorporates power connector, power switch, RS 232 port for GC connection, "Ext Start" connector and gas inlets.

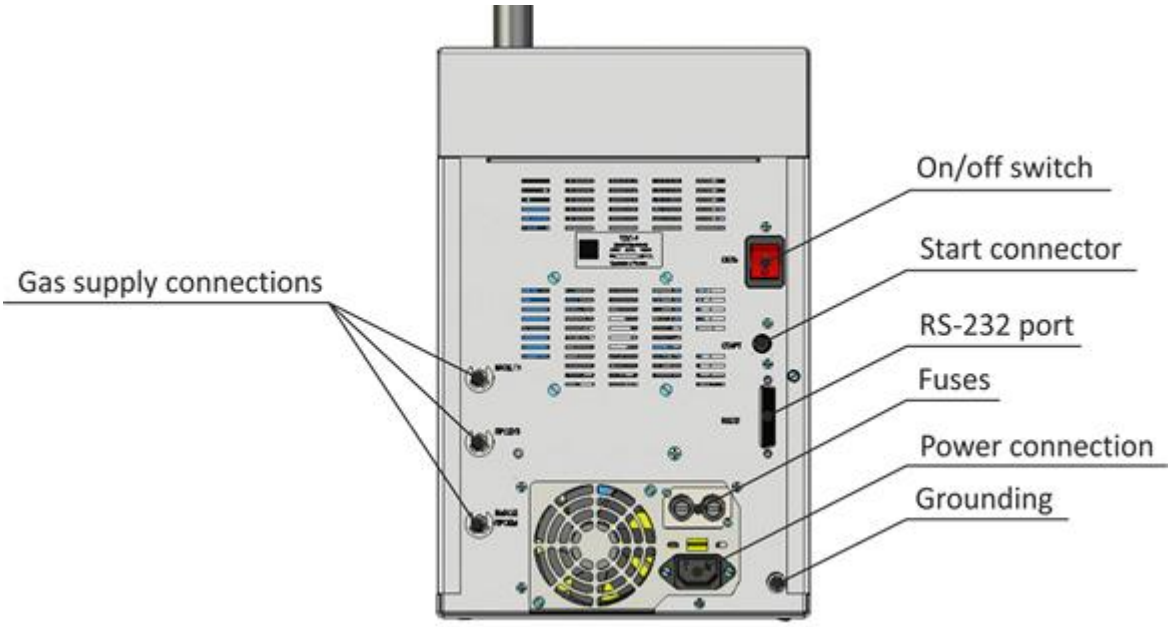


Figure 1.2 – Thermal desorber. Rear view

The Figure 1.3 shows a top view of thermal desorber with top cover removed.

Sample tube oven, switching valve and cold trap are located under top cover.

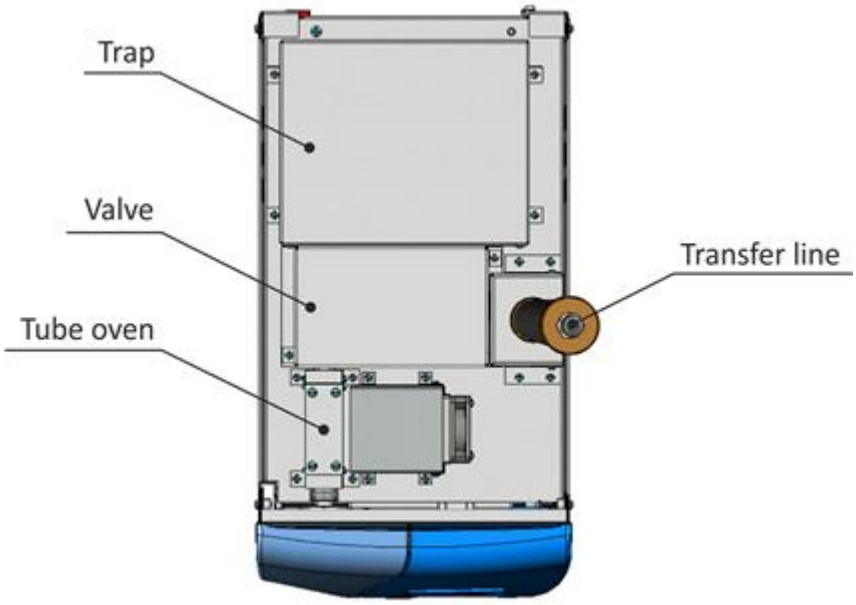


Figure 1.3 – Thermal desorber. Top view

Sample tube oven. This is used for thermal desorption of compounds from a sample tube. The oven represents a body with heater where sample tube is located. The front section of the oven features a removable adapter used to connect purge gas. The adapter may be secured with a nut.

Temperature of sample tube oven may be selected between (t_{amb}+10) to 400 °C and maintained at a set level during a specified time interval.

Cold trap. This is used to focusing compounds to be sample analysis. Cold trap represents a glass tube packed with sorbents. During thermal desorption of compounds from sample tube, trap is cooled by Peltier elements below ambient temperature. Once all the analytes have been collected in the cold trap, the trap oven is quickly heated to transfer compounds into chromatographic column.

During sample collection, trap temperature is set between – 20 and 35 °C, but when sample gets into chromatographic column trap temperature is set between 35 to 400 °C.

Valve. Two position switching 6-port thermally controlled valve provides gas flows switching. During thermal desorption step gas flow passes from the sample tube through the trap. At the beginning of analysis step, the valve switched and gas flow passes through the trap to GC column.

Valve temperature may be set between 150 and 250 °C and maintained at a constant level during all operation steps of thermal desorber.

Switching of the valve is controlled by electric drive. Valve position ("Desorption" or "Analysis") is tracked by sensors.

Transfer line. This is used to transfer sample from trap into chromatographic column. In order to avoid condensation of analytes, temperature of transfer line is permanently maintained at level set between 40 and 250 °C. At the end of the transfer line screwed the needle to introduce into the GC injector.

Carrier gas digital flow control (DFC). This is used to regulate carrier gas flow rate in transfer line. Carrier gas flow rate may be selected between 0 and 200 ml/min and maintained at a constant level during all operation steps of thermal desorber.

Purge gas digital flow control (DFC). This is used to flow regulation of purge gas passing through the sample tube. Purge gas flow rate is selected between 0 to 200 ml/min and automatically installed during the steps of desorption and tube conditioning.

Solenoid valves. These are used to shutoff purge gas flow in order to leak test of sample tube installation. Normally solenoid valves (in de-energized state) are closed.

Power supply. This is used to generate supply voltages needed for thermal desorber components.

Controller. This is used to store operation algorithms, method parameters, also, it maintains temperature in sample tube oven, trap, valve, transfer line. Also, it controls gas flow rates, electric drive of the valve, solenoid valves and communication between thermal desorber and GC.

Keyboard. This is used to select thermal desorber operation mode.

Display. This is used to view operation parameters.

Flow diagram of the thermal desorber is shown in the Figure 1.4 (valve in "Desorption" position).

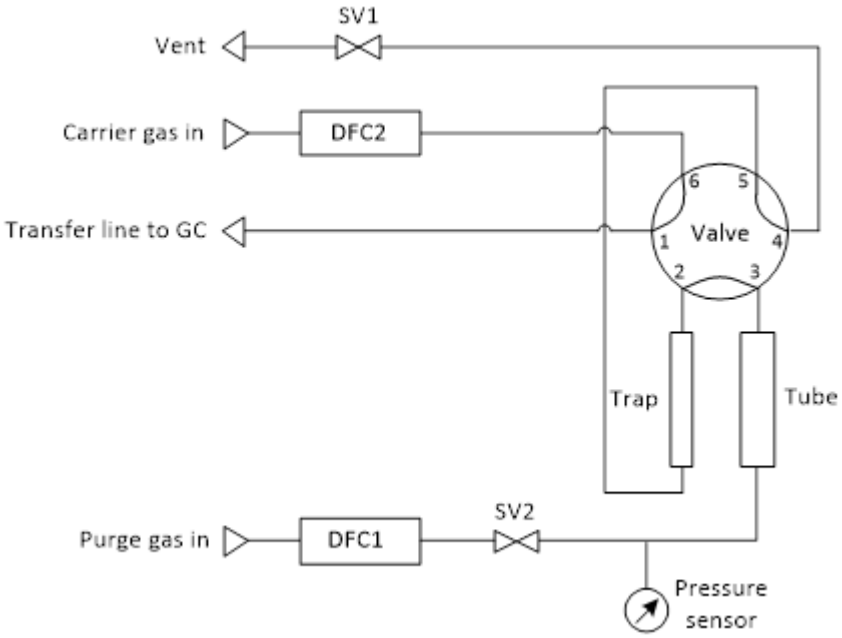


Figure 1.4 – Flow diagram of thermal desorber

1.5 Sequence of operation

The thermal desorber performance includes following steps in a specified order:

- preparation,
- desorption,
- analysis,
- tube conditioning.

1.5.1 Preparation

During preparation step, select a predetermined values of carrier gas flow rate and trap low temperature. Purge gas doesn't pass through sample tube. Switching valve stays in "Desorption" position.

When you turn on the thermal desorber, trap cooling and the carrier gas is carried out after valve heating above 150 ° C.

1.5.2 Ready

At ready step, a sample tube should be placed to the oven and analysis runs.

1.5.3 Desorption

Before thermal desorption, the sample tube should pass leak test by measuring pressure drop across tube. If pressure drop exceeds a specified value (the default settings is 1 kPa), system produces "Leak test failed" warning and returns to preparation step.

If the leak test is failed, after leak eliminating when the thermal desorber is ready must re-press the Start button on the thermal desorber.

After completing leak test, purge gas flow rate and temperature for sample tube oven are set. The selected values will be maintained during the specified desorption time.

At this step, analytes are transferred by purge gas from sample tube into the cold trap where they are concentrated.

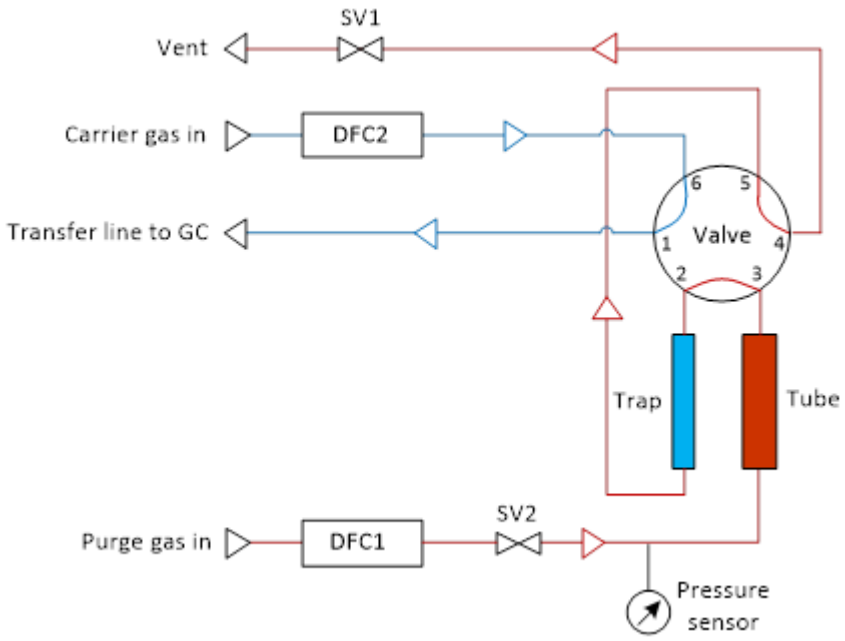


Figure 1.5 – Flow diagram in desorption step

1.5.4 Analysis

Switch valve into "Analysis" position, set trap high temperature and this will be maintained during a specified time interval. At this step, heating of the sample tube and purge gas are stopped.

During analysis step, compounds are desorbed from the trap and moved by carrier gas via transfer line into chromatographic column.

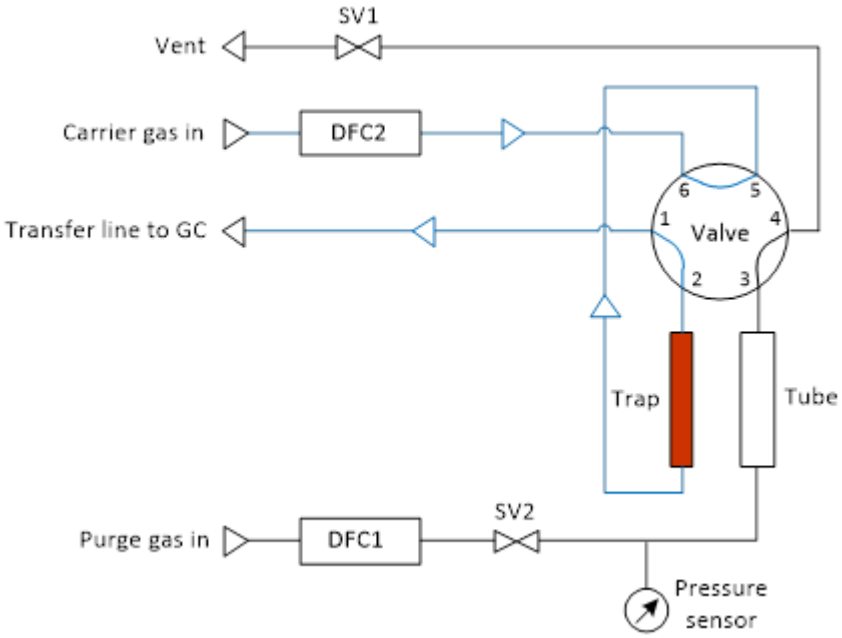


Figure 1.6 – Flow diagram in analysis step

1.5.5 Tube conditioning

Select a specified purge gas flow rate and temperature for the sample tube oven. The selected values will be maintained during a time interval set for tube conditioning.

Tube conditioning is used to remove volatile contaminants from a sorbent. After conditioning, tube is ready for next sampling.

1.6 Thermal desorber parameters

Operator set switching valve, sample tube and trap temperatures, carrier gas and purge gas flow rates and each operation step time via software or keyboard. All settings are set and controlled automatically by software. General settings can be selected in configuration parameters. Settings for each operation step can be selected in corresponding menu. For thermal desorber operation parameters and settings, see the Table 1. For detailed description of thermal desorber method development, see the Section 3.10.

Table 1.1 – Thermal desorber operation parameters

Parameter	Description
Configuration	
Valve temperature	Select between 150 and 250 °C. Valve heating is needed to prevent condensation of compounds. The recommended valve temperature for analysis of volatile organic compounds is between 180 and 200 °C.
Transfer line temperature	Select between 40 and 250 °C. The heated transfer line is used to transfer compounds from the trap into chromatographic column. Typically, transfer line temperature must be set by 5 – 10 °C higher than valve temperature.
Carrier gas	Select type of carrier gas: helium, nitrogen, argon, hydrogen.
Purge gas	Select type of purge gas that is used for desorption of compounds from sample tube: helium, nitrogen, argon.
Leak test	Select acceptable limit for pressure during leak test. The recommended value is 1 kPa.
Waiting ready	Select between YES and NO. When option is enabled, system goes to Analysis step after pressing Start button. This option is applicable for GC that cannot support communication with thermal desorber. Select NO to enable automatic start of GC.
Sound	Select between ON and OFF. When ON is selected, the thermal desorber produces beep tone to indicate that system is ready.
Preparation	
Tube temperature (initial)	Select temperature between 35 and 400 °C. This sets temperature of oven during sample tube installation. When "0" is selected, this parameter is disabled, i.e. temperature of sample tube oven corresponds to ambient temperature. The recommended value is 0 °C.
Trap temperature (low)	Select temperature between – 20 and 35 °C. This sets trap temperature during desorption of compounds from sample tube and their collection on a sorbent in the cold trap. The recommended value is between – 20 and – 10 °C. For desorption of samples with high humidity, set trap low temperature 4 °C.
Carrier gas flow rate	Select value between 0 and 200 ml/min. The recommended value is between 5 and 15 ml/min.
Stabilization time	Select value between 0 min 00 s and 15 min 00 s. This time is needed for stabilization of sample tube and trap temperatures.
Desorption	
Tube temperature	Select temperature between 35 and 400 °C. This sets temperature of sample tube oven during desorption of compounds. Desorption temperature depends on compounds and type of sorbent. See this value in corresponding measuring methods.
Purge gas flow rate	Select flow rate value between 0 and 200 ml/min. To ensure optimum desorption, it is recommended to set purge gas flow rate between 30 and 50 ml/min.

Parameter	Description
Desorption time	Select value between 00 h 00 min 00 s to 1 h 00 min 00 s. Value should be set in such a manner as to ensure a complete extraction in the shortest time.
Analysis	
Trap temperature (high)	Select temperature between 35 and 400 °C. Trap temperature depends on sorbent used.
Heating rate	Select between 500, 1000, 1500, and 2000 °C/min. The faster heating rates ensures that volatile compounds are transferred to the GC column during several second. Lower heating is used for analysis of thermally labile analytes.
Heating time	Select value between 0 min 00 s and 15 min 00 s. This sets a time during which trap will be heated. The recommended value is 1–2 min.
Tube conditioning	
Tube temperature	Select temperature between 35 and 400 °C. This sets an oven temperature for sorbent tube conditioning. Conditioning temperature depends on maximum operating temperature of sorbent. Typically, conditioning temperature must be set higher than desorption temperature by 10–20 °C.
Purge gas flow rate	Select flow rate between 0 and 200 ml/min. To decrease sample tube conditioning time, it is recommended to set purge gas flow rate 50–100 ml/min.
Conditioning time	Select value between 00 h 00 min 00 s to 24 h 00 min 00 s. Conditioning time should be selected in such a manner as to ensure that interfering peaks are not higher than 10 % of the typical areas of the analytes. The recommended tube conditioning time after analysis is between 10 and 15 minutes.
Delay time	Select value between 00 h 00 min 00 s to 24 h 00 min 00 s. Delay time might be set for sequential analyses in such a manner as to ensure that thermal desorber becomes ready for next analysis as GC does. Typically, the delay time is set 0.

There are two ways to set the analysis parameters:

- by using thermal desorber keyboard;
- by using PC (Chromatec Analytic software).

In the first case, the operator must manually synchronize the analysis on the thermal desorber and the GC.

Diagram of the control signals of the thermal desorber controller:

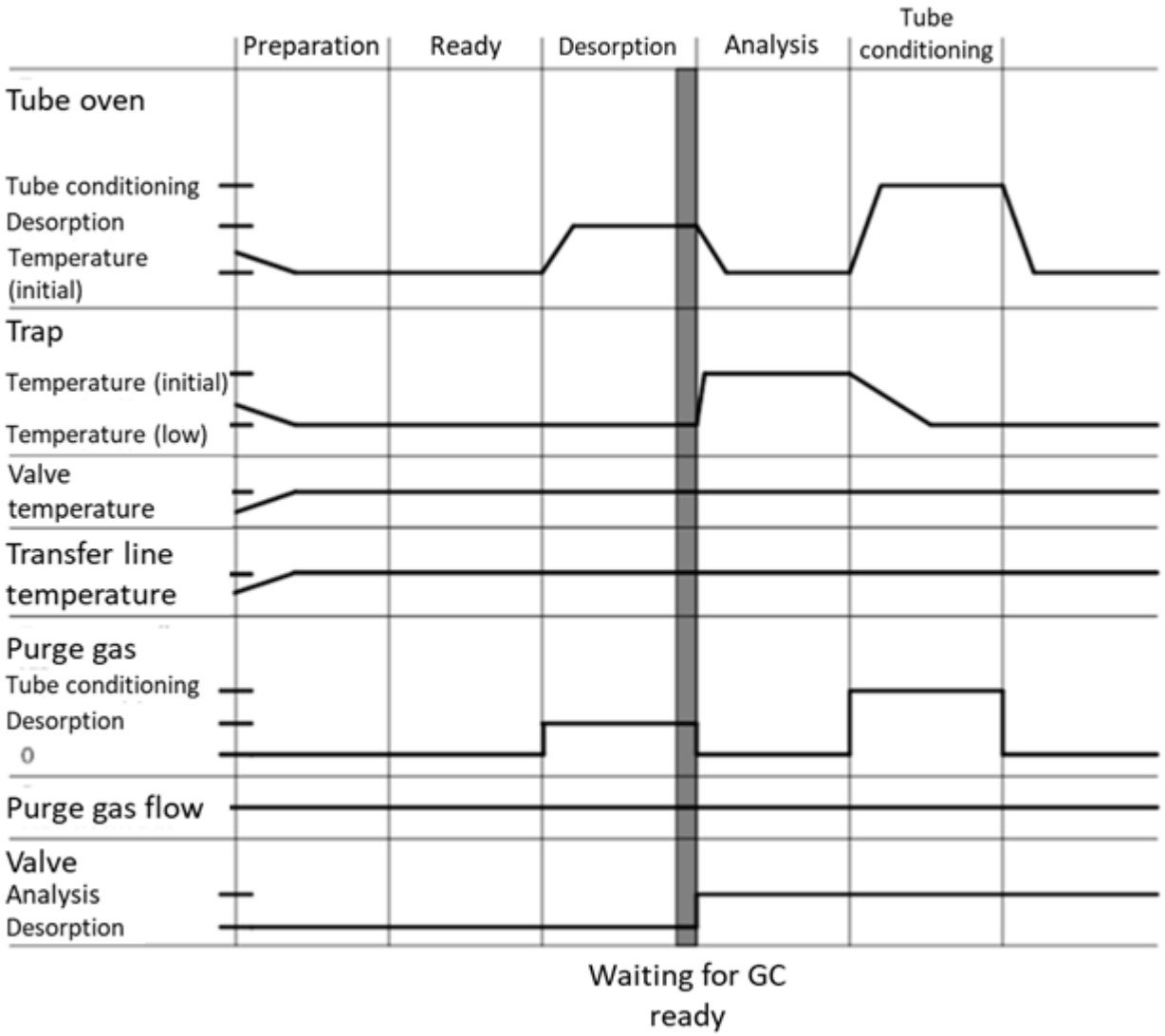


Figure 1.7 – Diagram of the control signals of the thermal desorber controller

Synchronization of thermal desorber and chromatograph operation can be performed in two ways: by chromatograph start or by thermal desorber start.

When the chromatograph is started, the "Desorption" stage is started by pressing the "Start" button on the chromatograph. After the end of the "Desorption" step, the "Analysis" step is started simultaneously on the thermal desorber and the chromatograph.

When working on the thermal desorber start, the transition to the "Desorption" stage is performed by pressing the "Start" button on the thermal desorber. After the end of the "Desorption" stage the thermal desorber waits until the chromatograph is ready and then simultaneously starts the "Analysis" stage on the thermal desorber and the chromatograph.

Program control of the thermal desorber is possible:

- from the keyboard of the thermal desorber;
- from the computer (program " Chromatec Analytic" version 2.6 and higher).

In the first case, the operator coordinates the operation of thermal desorber and chromatograph.

1.6.1 Thermal desorber control via keyboard

The keyboard is located on the front panel of the thermal desorber and features 11 buttons. For user convenience, display is located near the keyboard. All operation steps of thermal desorber are indicated by LEDs.



Figure 1.8 – Thermal desorber keyboard

When pressing a button, first parameter corresponding to that button appears on display. With ▲ and ▼ buttons you can view in display all parameters corresponding to each functional button.

Start

During off mode step, button **Start** can be pressed to start method.

At the Ready step button **Start** makes a transition to the Desorption step.

If waiting ready option is enabled, during Desorption step button **Start** can be pressed to go to Analysis step.

Stop

Pressing button **Stop** aborts method execution without any possibility to continue it. When starting method again, it will be started from the beginning.

Status

Pressing button **Status** shows on display current and selected operation parameters of thermal desorber:

- Step name.
- Step time.
- Sample tube temperature.
- Trap temperature.
- Valve temperature.
- Transfer line temperature.
- Carrier gas flow rate.
- Purge gas flow rate.

Config

Pressing button **Config** opens configuration settings.

In the configuration menu, following settings are available:

- Valve temperature.
- Transfer line temperature.
- Carrier gas type selection.
- Purge gas type selection.
- Acceptable pressure drop during leak test.
- Waiting ready.
- Sound.

The set values and unit of measurements are shown for each parameter. Parameter value can be changed by pressing **+**, **–** and **Enter** buttons. To abort recent change, press button **Back**.

Set

The button **Set** is used to get access to method edit menu and parameters edit menu throughout all operation steps of thermal desorber.

When selecting **Change method** parameter, step selection menu appears.

For Preparation step following parameters may be set:

- Sample tube temperature (initial).
- Trap low temperature.
- Carrier gas flow rate.
- Stabilization time.

For Desorption step following parameters may be set:

- Sample tube temperature (desorption).
- Purge gas flow rate.

- Desorption time.

For Analysis step following parameters may be set:

- Trap high temperature.
- Heating rate.
- Heating time.

For Tube conditioning step following parameters may be set:

- Sample tube temperature (conditioning).
- Purge gas flow rate.
- Conditioning time.
- Delay time.

The set values and unit of measurements are shown for each parameter. Parameter value can be changed by pressing **+**, **–** and **Enter** buttons. To abort recent change, press button **Back**.

To save method return to **Programming** menu by pressing button **Back**, select **Save method** option, enter method number and press button **Enter**.

1.6.2 Thermal desorber control by using Chromatec Analytic software

Operator's actions when working in the "Chromatec Analytic" program are described in the User Manual 214.00045-51I.

Setting the thermal desorber operation parameters is done simultaneously with setting the chromatograph instrumental method before starting measurements.



If Chromatec Navigator is not running, start it.



Then start the connection using the button on the desktop " Chromatec Navigator". The "Control Panel" and " Chromatec Analytic 3.1" programs will be loaded.



Go to the **Method** page.



In the sidebar, click the **Peripherals** button.

Setting of the thermal desorber parameters is performed simultaneously with the GC method setting.

In the Control Panel software method parameters are set in the dialog box Method, section Thermal desorber. The description of each parameter is given in the Table 1.

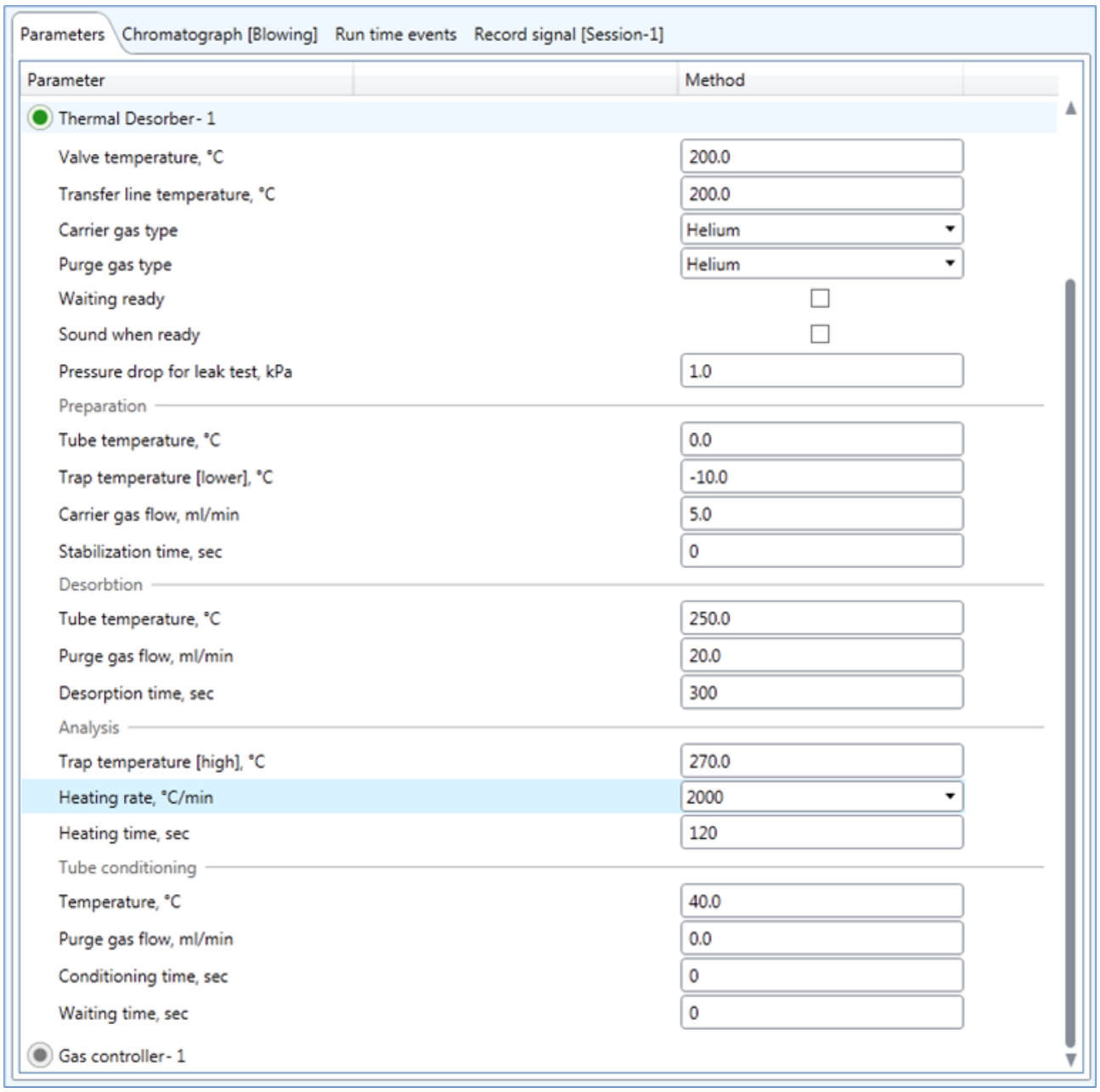


Figure 1.9 - Thermal desorber method in "Control Panel 2.0"

2 Operation

2.1 Safety provisions

The thermal desorber can be used by person familiar with the present manual and having adequate skills and knowledge to operate this device.

The thermal desorber should be grounded. For grounding, use power plug and grounding terminal pro-vided on the rear side of sampler. For thermal desorber connection, the "⏚" terminal of mains socket must be connected to external grounding loop by copper wire with cross-section of at least 1.5 mm^2; terminal must be connected to grounding loop using cable 6.644.056 included to Shipping kit.

DO NOT USE thermal desorber with removed covers**!**

Before technical maintenance disconnect the power cord from power mains and close gas source.

When using flammable, hazardous or aggressive substances, including those dedicated for syringe washing, observe safety fire precautions specified in national standard GOST12.1.004-91. Also, observe precautions specified in relevant instructions prepared by User (according to substances used) based on national standard GOST 12.1.007-76.

When the thermal desorber will not be used for a long time, disconnect it from power supply and close gas line.

2.2 Preparing to work

The thermal desorber should be prepared for operation with disconnected power supply and closed gas lines.

2.2.1 Placing the thermal desorber

The thermal desorber must be positioned to the left of the GC (or GC/MS).

For effective cooling of electronic assemblies, minimum distance between the thermal desorber and the GC must be 5 cm. Also, consider that length of the transfer line is 1 meter.

Thermal desorption is a very sensitive method of analysis. So, install the thermal desorber in a room where no organic contaminants in the air.

2.2.2 GC preparing

Before GC preparing cool the inlet to avoid getting burned.

- Install the liner 7.352.066 in the GC inlet.
- In the GC inlet replace the nut 6.482.013 to the nut 8.936.107 as shown in the Figure 7.

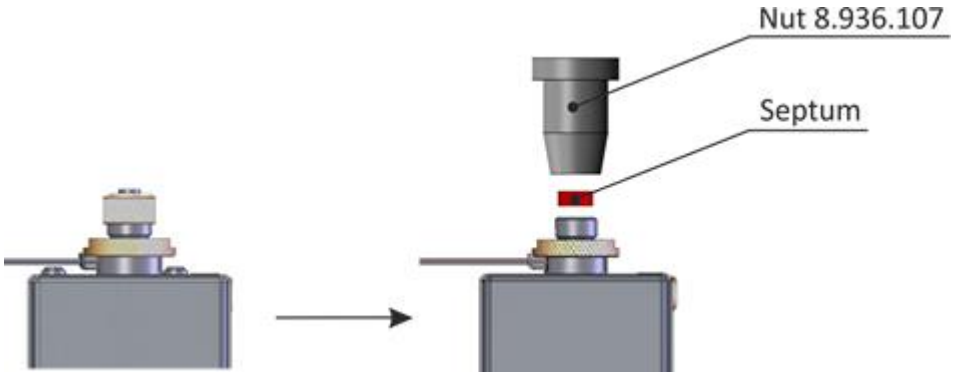


Figure 2.1 – Preparing GC injector

2.2.3 Connecting the gas supplies

It is required to use inert gas with purity at least 99.999 %.

It is recommended to install hydrocarbons, moisture and oxygen filters for gas lines.

Maximum allowable pressure level is 0.64 MPa.

Do not use hydrogen as purge gas!

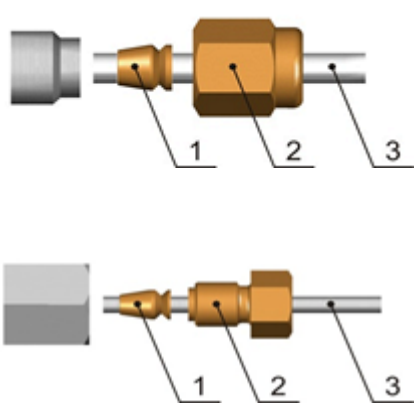
Use clean copper or stainless-steel tubing for gas connection. To remove any contaminants, bake the tubing in an oven and pass a clean inert gas through it.

The thermal desorber has separate gas connectors for carrier and purge gases. You can use different gases for tube and trap desorption.

Input fittings for gas supply connection are located on the rear panel (Figure 1.2).

- Connect the carrier gas line that is used in the GC to the Carrier inlet port.
- Connect the purge gas line that will be used during tube desorption to the Purge inlet port.
- Remove the cap from the Vent fitting and leave it non-connected.

For tube connection see the Figure 2.2. All connections should be made with metal tubes and metal ferrules. Ferrules should be tightened by hand followed by tightening with spanner to 60°.



1 – Ferrule 8.658.038-03

2 – Nut 8.930.167-04

3 – Tube, O.D. 3 mm

1 – Ferrule 8.658.039-01

2 – Nut 8.930.161-03

3 – Tube, O.D. 1.6 mm

Figure 2.2 – Tube connections

To avoid analytes tailing, completely insert the tube ends into connectors and continuously check tube position during sealing.

After connecting the gas lines should be checked for leaks.

2.2.4 Power connection

The area of mounting should be provided with single-phase alternative current mains with voltage 220 V ± 10 %, frequency 50 ± 1 Hz and grounding line (circuit).

Connect the thermal desorber to a power supply using the cable SCZ-1.

2.2.5 Trap installation

The thermal desorber is supplied with a Tenax TA trap installed. If it is necessary to use a trap with a different sorbent, replace the trap according to section 5.3.2.

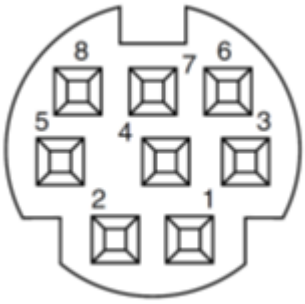
2.2.6 Connecting the thermal desorber to the GC

Connection between the thermal desorber and the Chromatec GC is made at RS-232 port, which is located on the rear panel. This port is used to send method from the control panel (PC) and to synchronize the thermal desorber and the GC (ready and start signals).

Connect RS-232 port of the thermal desorber to AUX port of the GC using cable RS-232-25/25.

For connecting the thermal desorber to a non-Chromatec GC use the Start connector on the rear panel.

Remote input signals are open collector type, remote output signals are TTL. Low voltage is logic zero, high voltage is logic one. The typical voltage is 5 V. A voltage over 2.4 V is considered as a high logic state, a voltage below 0.8 V is considered as a low logic state.



1 – Remote Start In

2 – Inhibit Ready

3 – Digital Ground

4 – Start Run

5 – Ready Out

6 – Not Used

7 – Not Used

8 – Not Used

Figure 9 – Start connector

Remote Start In – The signal from the GC to start the thermal desorber.

Inhibit Ready – Analysis start delay until the thermal desorber receives a ready signal from the GC.

Start Run – The signal from the thermal desorber to the GC that the run has started.

Ready Out – The signal to the GC that the thermal desorber is ready.

2.2.7 Connecting the transfer line to the GC

- Loosen the nut 8.936.107.
- Puncture the injector membrane by needle of the transfer line.
- Tighten the nut 8.936.107.

2.3 Operating procedure

2.3.1 Setting the thermal desorber operation parameters

Possible variants of thermal desorber operation control and operation parameters are given in section 1.5.

Setting the thermal desorber operation parameters using the keyboard.

The procedure of working with the thermal desorber keyboard is described in section 1.5.1.

Algorithm of setting the thermal desorber operation parameters using the keyboard:

- Press the key "Config" and in the menu that appears enter the necessary parameters.
- Press the key "Prog" and select the command "Change method".
- In the appeared list of steps set the necessary parameters one by one.

- After all parameters have been set, return to the "Program" menu, select the method number in the "Run method" line and press the "Enter" key to save the changes.
- Start the method execution by pressing the "Start" key.

The thermal desorber parameters are monitored on the indicator by pressing the "Status" key.

Setting the parameters of thermal desorber operation in the program "Chromatec Analytic".

The procedure of work with the program "Chromatec Analytic" is described in section 1.5.2.

Algorithm of setting parameters of thermal desorber operation in the program "Chromatec Analytic":

- Start the Control Panel.
- In the "Control" menu select the "Mode" command.
- In the "Mode" window select "Thermal desorber TDS-1".
- In the dialog box that appears, enter the required parameters.
- Press the "OK" button.

Parameter control is displayed in the "Status" tab.

2.3.2 Installing the sorption tube in the thermal desorber thermostat

A sorption tube filled with sorbent is shown in the figure below. Each tube is labeled with a sorbent symbol (see appendix).

The tube packed with one sorbent is shown in the Figure 2.3.

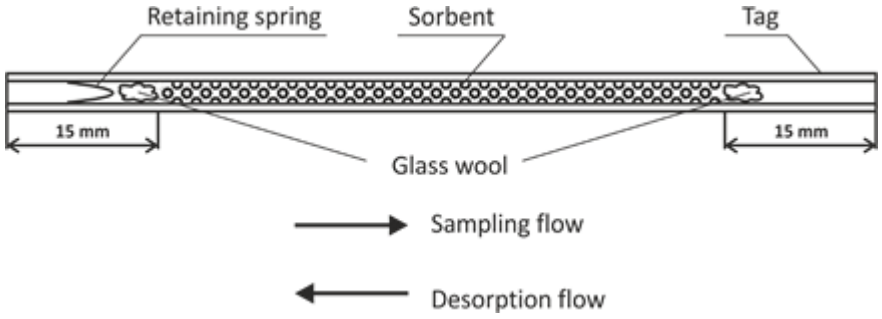
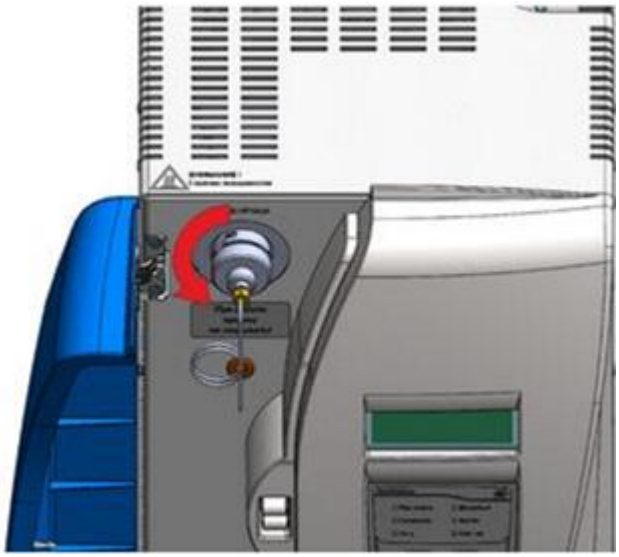


Figure 2.3 – Single bed sorbent tube

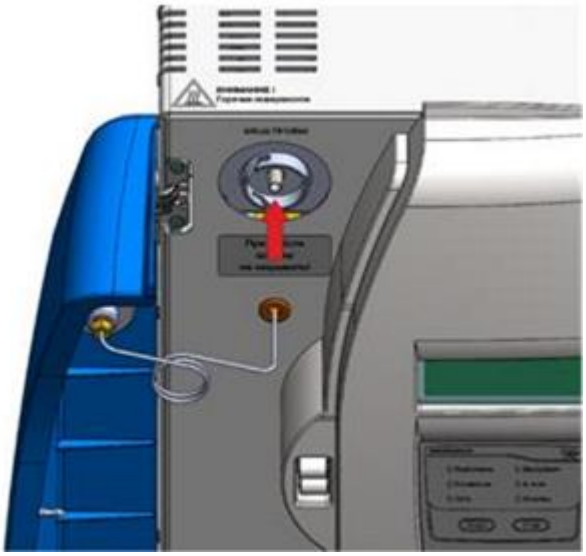
The sorption tube is installed in the thermal desorber thermostat at the "Ready" stage.

To install the sorption tube it is necessary to:

- Disconnect the bayonet by pushing it slightly and turning it counterclockwise.



- Insert the sorption tube into the thermostat, the tube marking must be on the bayonet side (at the front of the thermostat).



- Connect the bayonet by pushing it in and turning it clockwise.
- After installing the sorption tube, press the "Start" key on the thermal desorber panel (when working with the PM3 chromatograph) or the "Start" key on the chromatograph panel (when working with the PM2 chromatograph). The thermal desorber moves to the "Desorption" stage.



To avoid burns, the sorption tube may be removed from the thermostat when its temperature is less than 50 °C.

2.3.3 Procedure for performing the analysis

After installation of the sorption tube and switching the thermal desorber to the "Desorption" stage, the sorption tube is heated in the thermostat to the set temperature and gas is blown through it, carrying the analyzed components into the trap.

If "Pre run" is set, the thermal desorber will wait for the "Start" key to be pressed (the "Ready" indicator will be lit). If "Waiting for Start" is not set, the thermal desorber will move to the "Analysis" stage immediately after the chromatograph is ready.

During the " Analysis" stage, the valve is turned to the " Analysis" position and the trap is quickly heated to the set temperature. The "Analysis" indicator on the thermal desorber panel illuminates. The chromatograph proceeds to the " Analysis " step.

After completion of the "Analysis" step, the thermal desorber moves to the "Tube conditioning" step. When the " Tube conditioning " step is complete, the thermal desorber moves to the "Preparation" step.

After completion of the thermal desorber can be switched off without waiting for all components (switch valve, transfer line, sorption tube thermostat) to cool down.

2.4 Checkout procedure

To check the thermal desorber performance use the GC with the flame ionization detector (FID) and the capillary column BPX-Volatile 60 m × 0.32 mm × 1.8 µm (also, you can use a column with another phase and length capable to separate analytes) and the sorbent tube Tenax® TA. To checkout use a test mixture toluene in methanol (or acetone) with concentration between 0.1 and 1.0 mg/ml.

Set GC method parameters as specified in the Table 2.1. The column temperature and the carrier gas flow is given to the column BPX-Volatile 60 m × 0.32 mm × 1.8 µm. When you use other column analysis parameters are selected to ensure the separation of solvent and toluene.

Table 2.1 – Checkout method

Parameter	**Value**
Column temperature	150 °C
Inlet temperature	200 °C
Carrier gas flow (helium)	1.5 ml/min
Split	1:20
FID temperature	250 °C
Hydrogen flow	25 ml/min
Air flow	250 ml/min
Make-up flow	25 ml/min

Set thermal desorber method parameters as specified in the Table 2.2.

Table 2.2 – Checkout method

Parameter	**Value**
Valve temperature	150 °C
Transfer line temperature	180 °C
Carrier gas	helium
Purge gas	helium
Leak test	1 kPa
Preparation	
Tube temperature	0 °C
Trap temperature (low)	-10 °C
Carrier gas flow	5 ml/min
Desorption	
Tube temperature	250 °C
Purge gas flow	30 ml/min
Desorption time	5 min (300 s)
Analysis	
Trap temperature (high)	250 °C
Heating rate	2000 °C/min
Heating time	2 min (120 s)
Tube conditioning	
Trap temperature (high)	270 °C
Purge gas flow	50 ml/min
Heating time	5 min (120 s)

Analysis procedure:

- Inject 1 µl of the text mixture into the sorbent tube from no-tag side.
- Purge tube with the inert gas in direction that coincides with sampling direction (Figure 2). Purge gas volume depends on type of solvent (Table 3.7).
- Insert the sample tube into the oven (see Section 2.2.4).
- Make a series of 5-10 analyses.

- Calculate the RSD in accordance with the chromatograph verification procedure. The RMS should meet the requirements specified in section 1.2.

When checking the readiness of thermal desorber for use, it is allowed to use other detectors, chromatographic columns, set other parameters of thermal desorber and chromatograph operation and other conditions of measurements, stipulated by the normative documentation on the analysis (GOST, MUK, MBI, etc.). In this case, the requirements for convergence of results between parallel measurements (control of relative RSD) are also specified in this normative documentation.

A typical chromatogram is shown in the Figure 15.

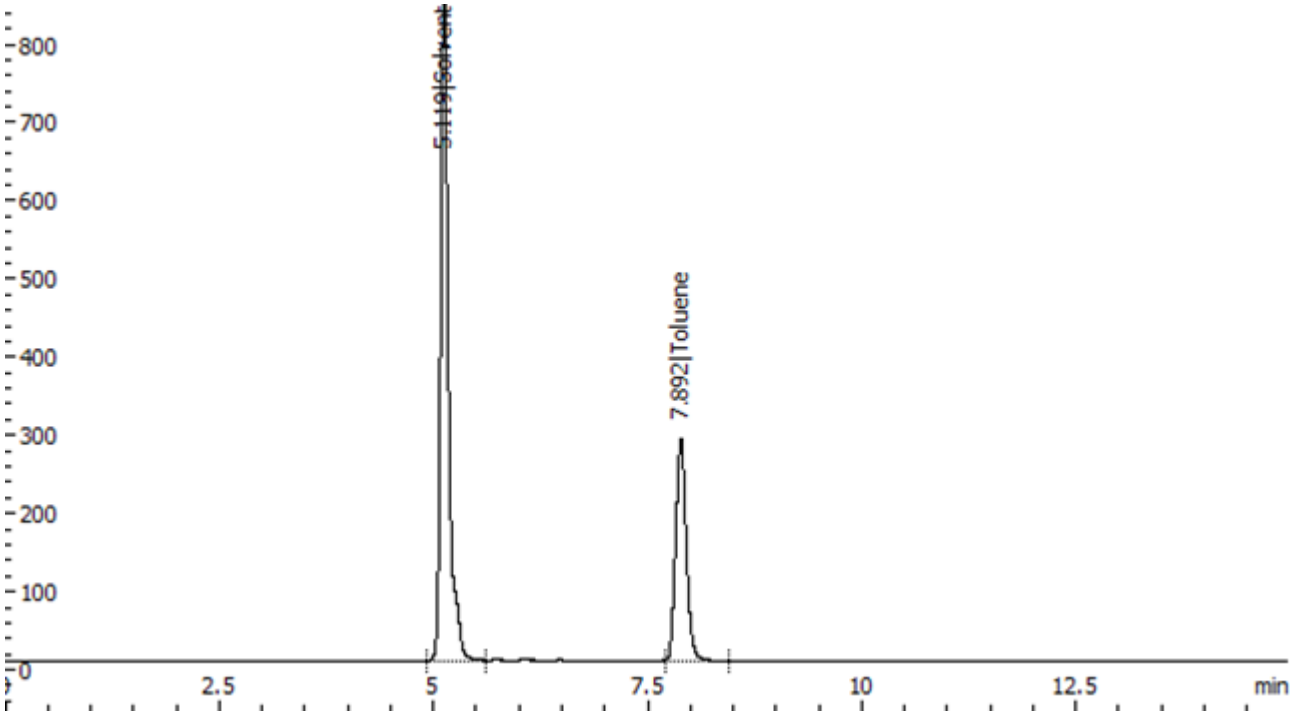


Figure 2.4 – Checkout chromatogram

3 Method development

3.1 Thermal desorption basics

The thermal desorption method consists in extracting volatile compounds from a sorbent when it is heated with inert gas flow. Then, these compounds are transferred to the GC.

The simplest version refers to a single stage thermal desorption (Figure 3.1). In this case compounds are moved directly from sample tube into chromatographic column. As sorbent content in tube is relatively large, it is impossible to ensure rapidly desorption of compounds. This leads to appearance of broad peaks which impair chromatographic separation.



Figure 3.1– Single stage thermal desorption

To ensure a narrow band of analytes in chromatographic column, two stage thermal desorption is used. During two stage thermal desorption components refocused onto trap, from which they are transferred in a narrow band to a chromatographic column (Figure 3.2). Two focusing methods are available:

- cryofocusing in a capillary;
- cold trapping.

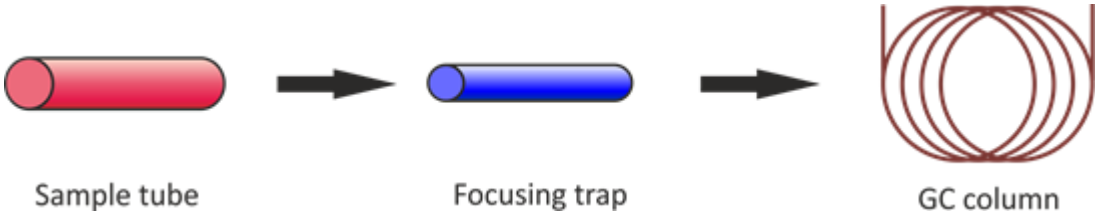


Figure 3.2 – Two stage thermal desorption

The cryofocusing occurs in quartz capillary with inner diameter between 0.18 and 0.53 mm being immersed into liquid nitrogen. The cryofocusing is a preferable method for focusing a ultra volatile compounds. However, this method has a certain disadvantage. At first, this method leads to higher liquid nitrogen consumption. At second, moisture contained in the sample tube may lead to capillary blockage.

Alternative method to focusing is a compound trapping by trap. Trap is packed with sorbent and cooled by Peltier elements. The sorbent allows concentrating even very volatile compounds without using liquid nitrogen. At the same time, lower sorbent volume allows to ensure rapid desorption and transferring sample into chromatographic column as a narrow band.

3.2 Thermal desorption applications

The main application of thermal desorption is analysis of volatile and semi-volatile organic compounds in ambient, workplace and indoor air. Also, it is used to test emissions of building materials and consumer products.

The thermal desorption also is used to analysis volatile organic compounds in solid samples, for example, to determine residual solvents in pharmaceutical products, packing materials, monomers in polymers, odors and flavors in food products, etc.

The thermal desorption also can be used to analysis different components that can be determined by gas chromatography. Range of analytes is limited by volatility and compounds with boiling temperature above 400 °C will be determined non-quantitatively. The thermal desorption cannot be used to analysis compounds with decomposition temperature below desorption temperature.

3.3 Method development objectives

The method development assumes the following objectives to be achieved:

- Sampling from an air to a sorbent without breakthrough.
- Completely desorption analytes from a sorbent tube.
- Completely retention analytes into a cold trap.
- Quantitatively transfer compounds to chromatographic column as narrow band as possible.
- Avoid influence of artifacts during sampling and analysis.

These objectives can be achieved by selecting a proper sorbent, sampling conditions and thermal desorber operation parameters.

3.4 Sorbent selection

During sampling sorbent should retain analytes while during desorption it should easily give it off. Depending on analytes, various sorbents can be used. Recommendations for sorbent selection see in the Table 3.1.

Depending on components sorption capability, sorbents are divided to weak, medium and strong. Weak sorbents are well in retaining semi-volatile compounds, medium – volatile, strong – highly volatile.

If sample represents a mixture of components with wide boiling temperature range, it is recommended to use tubes packed with several layers of different sorbents. In this case select sorbent having closer desorption temperatures (difference should not exceed 50 °C). Otherwise, you cannot condition more heat-resistant sorbent without destruction that having less resistance to temperature.

If sample mixture is unknown, it is recommended to use multiple beds sorbent tubes packed with following sorbents: Carbopack™ C, Carbopack™ B and Carbosieve® S-III. Such sample tubes can retain virtually all compounds.

Table 3.1 – Sorbent selection recommendations

Sorbent	Range of analytes volatility	Maximum operating temperature, °C	Specific surface area, m2/g	Analyte examples
Tenax® TA	boiling point 100 to 400 °C. n-C7 to n-C26	350	35	Aromatic non-polar compounds (with boiling point above 100 °C) and less volatile polar compounds (with boiling point above 150 °C)
Tenax® GR	boiling point 100 to 450 °C. n-C7 to n-C30	350	35	Alkylbenzenes, aromatic polycyclic hydrocarbons and polychlorinated biphenyl, also compounds specified for Tenax® TA
Porapak™ Q	boiling point 50 to 200 °C. n-C5 to n-C12	250	550	Different volatile organic compounds, including oxygen containing compounds
Porapak™ N	boiling point 50 to 150 °C. n-C5 to n-C8	180	300	Specific adsorbent for volatile nitriles: acrylonitrile, acetonitrile, propionitrile, also suitable for pyridine, volatile alcohols from ethanol, methyl ethyl ketone, etc.
Carbopack™ B	n-C5 to n-C14	400	100	Different volatile organic compounds, including ketones, alcohols, aldehyde (with boiling point above 75 °C), all non-polar compounds within specified volatility range and perfluorocarbon tracer gases
Carbopack™ C	n-C8 to n-C20	400	12	Alkylbenzenes and aliphatic compounds
Carbosieve® S-III	boiling point – 60 to 80 °C. n-C2 to n-C5	400	800	Ultra volatile compounds from ethane, volatile halogen-containing compounds and freons
Carboxen® 1000	boiling point – 60 to 80 °C. n-C2 to n-C4	400	1200	Ultra volatile hydrocarbons, volatile halogen-containing compounds and freons

Before sorbent tube packing, sorbent should be conditioned according to manufacturer recommendations. If no recommendations are available, sorbent conditioning should be held for 15-20 hours in inert gas flow at temperature by 25 °C below maximum operating temperature.

3.5 Packing sorbent tubes

For the thermal desorber is used sorbent tubes with length 115 mm and O.D. 6 mm. Sorbent tubes may be made of glass, stainless steel or other inert material. For labile analytes, such as sulfur-containing compounds, use glass tubes.

Typically, tubes are packed with 200-1000 mg of a sorbent depending on it's density, eg, approx. 250 mg for porous polymers (Tenax®, Porapak™) or 500 mg for carbon sorbents (Carbopack™, Carbosieve®). The recommended sorbent size is 60/80 mesh.

The length of sorbent layer should not exceed heating zone, but should be at least 15 mm away from either tube end. To hold sorbent in a glass tube, glass wool or quartz wool is used. Length of glass wool layer should be approx. 5 mm. To hold sorbent in a stainless-steel tubes, gauze ring, glass wool or quartz wool is used.

For analysis of labile components, you can secure sorbent layer in a tube with silanized glass wool. In this case, maximum tube temperature must not exceed 250 °C.

The tube packed with one sorbent is shown in the Figure 3.3.

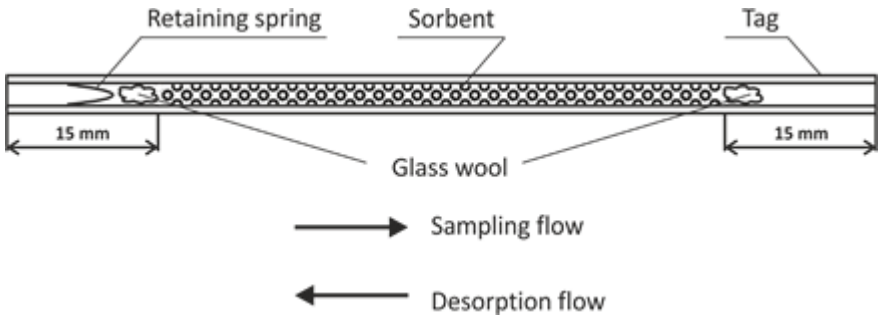


Figure 3.3 – Single bed sorbent tube

If the tube is packed with several sorbents, they should be located in ascending order regarding their strength and separated between each other with a glass wool. The strongest sorbent should be located from tube side where tag is attached. So, a sample will enter in direction from weak towards strong sorbent in such a manner as semi-volatile compounds will be retained by weak sorbent while highly volatile components by strong one. Desorption occurs in reverse direction and semi-volatile compounds do not contact with strong sorbent as it could lead to their irreversible sorption (Figure 3.4).

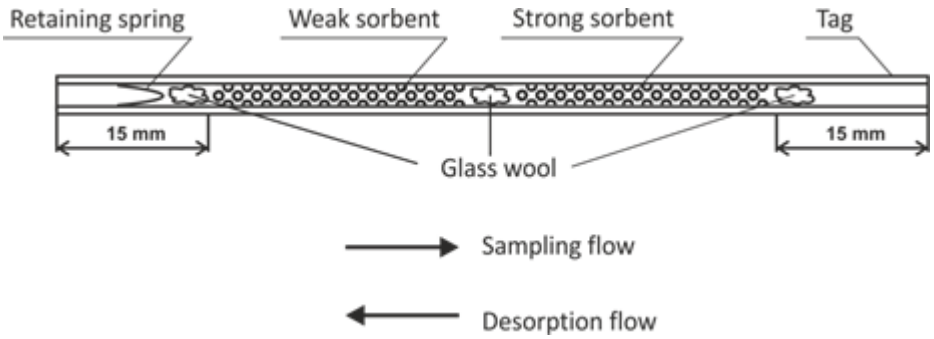


Figure 3.4 – Multiple beds sorbent tube

For possible options of packing tubes with several sorbents, see Table 3.2.

Table 3.2 – Multiple beds sample tubes

First layer	Second layer	Third layer
Tenax® TA	Carbopack™ B	–
Tenax® GR	Carbopack™ B	–
Tenax® TA	Carboxen® 1000	–
Tenax® TA	Carbosieve® S-III	–
Tenax® GR	Carboxen® 1000	–
Tenax® GR	Carbosieve® S-III	–
Carbopack™ B	Carbosieve® S-III	–
Carbopack™ B	Carboxen® 1000	–
Tenax® TA	Carbopack™ B	Carboxen® 1000
Tenax® TA	Carbopack™ B	Carbosieve® S-III
Tenax® GR	Carbopack™ B	Carboxen® 1000
Tenax® GR	Carbopack™ B	Carbosieve® S-III
Carbopack™ B	Carbosieve® S-III	Carboxen® 1000
Carbopack™ C	Carbopack™ B	Carboxen® 1000
Carbopack™ C	Carbopack™ B	Carbosieve® S-III

It is recommended to re-pack the tubes with a new sorbent each year or after 100 analyses.

3.6 Conditioning sorbent tubes

Sorbent tube conditioning is used to remove volatile contaminants from a sorbent. The conditioning may be carried out directly in the thermal desorber (during Tube conditioning step) or in a desorber unit (special device for conditioning sorbent tubes).

When proceeding with conditioning for the first time, it would be preferable to smoothly increase temperature after each three or four steps. For first time conditioning, temperature should be set by 20-30 °C above desorption temperature. To ensure quick removal of contaminants, apply higher inert gas flow rate (approx. 100 ml/min). For a new tube, conditioning time depends on sorbent type and temperature, but anyway it should be not less than 1 hour.

For the next tube conditioning, you can set temperature by 10-20 °C above desorption temperature for a time between 15 and 30 minutes.

Conditioning temperature must not exceed maximum operating temperature of sorbent (Table 3.1).

For recommended maximum temperatures for tube conditioning depending on sorbent, see Table 5. For multiple beds tubes, conditioning temperature must be selected for a least thermally

stable sorbent. For example, maximum conditioning temperature for tubes packed with Tenax® GR, Carbopack™ B and Carbosieve® S-III must be 330 °C.

Table 3.3 – Recommended maximum conditioning temperatures

Sorbent	**Maximum conditioning temperature, °C**
Tenax® TA	330
Tenax® GR	330
Porapak™ Q	250
Porapak™ N	180
Carbopack™ B	350
Carbopack™ C	350
Carbosieve® S-III	350
Carboxen® 1000	350

For tube conditioning in the thermal desorber, reset time values of Desorption and Analysis steps to skip them and start operation instantly from a tube conditioning.

After conditioning, check the tube by blank analysis. If any contaminant is revealed, repeat conditioning once more.

3.7 Sampling

Sampling can be done by purging air through the sample tube using a sampling pump with a constant flow rate during a specific time.

The pump must provide maximum air sampling rate of 200 ml/min at backpressure of 5 kPa.

Sampling can be done using a connector 8.652.506 or 8.652.507. Selection between these connectors depends on inlet port of a pump.

For connection diagram, see Figure 20. All parts needed for connection are included to shipping kit. The tube should be connected to pump with a marked end. For multiple beds tubes, sample should at first pass through a weak adsorbent and then through a strong one.

The recommended air flow rate through the sample tube is between 50 and 200 ml/min. The specified flow rate range is limited by the following factors: at a lower flow rate, diffusion of analytes leads to a significant error while at a higher flow rate analytes could be break through the tube.

Volume of air to be pumped through the tube depends on a specific analysis method. Minimum sample volume depends on detector sensitivity while maximum depends on an adsorption capability.

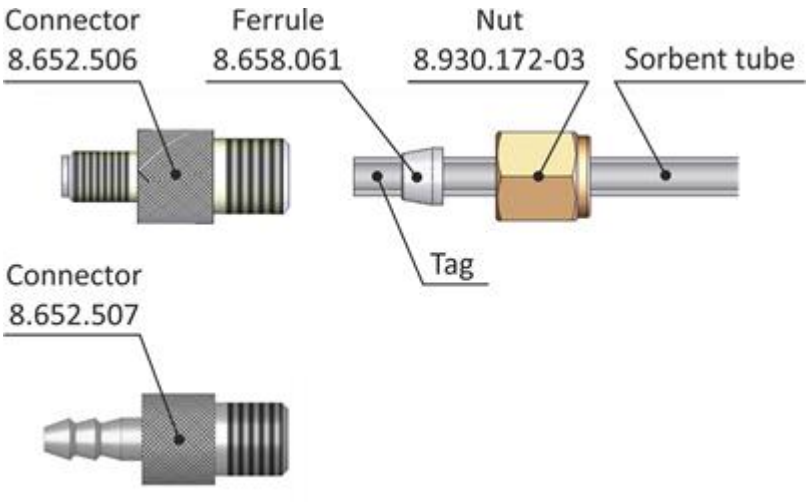


Figure 3.5 – Sample tube connection

The Table 3.4 illustrates estimated masses of analytes and retained by adsorbent depending on sample type and pumped air volume.

Table 3.4 – Mass of analytes retained by adsorbent depending on sample type

Sample type	**Expected concentration, µg/m3**	**Mass of analytes, ng, for a specific air volume**		
		1 L	2 L	10 L
Polluted urban area	10 – 1000	10 – 1000	20 – 2000	100 – 10000
Indoor environment	5 – 500	5 – 500	10 – 1000	50 – 5000
Normal urban area	5 – 50	5 – 50	10 – 100	50 – 500
Normal rural area	0.5 – 5	0.5 – 5	1 – 10	5 – 50
Forest	1 – 10	1 – 10	2 – 20	10 – 100
Cleaned air	0.1 – 20	0.1 – 20	0.2 – 40	1 – 200

Adsorption capability describes breakthrough volume and retention volume.

Breakthrough volume – volume of test atmosphere that can be passed through a sorbent tube before the concentration of eluting vapor reaches 5 % of the concentration in the initial mixture.

The breakthrough volume can be determined using calibration gas mixtures with concentrations between 1 and 10 mg/m^3. In this case you need a system comprising of calibration gas mixture source, needle valve, flow meter, sorbent tube and PID or another detector (Figure 3.6).

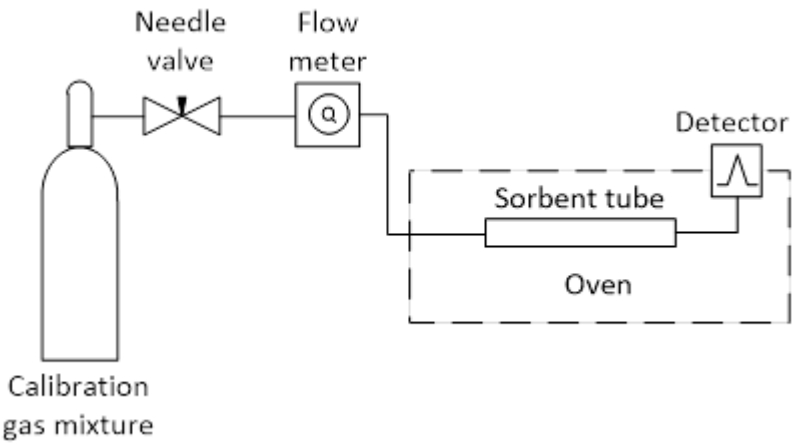


Figure 3.6 – Diagram for breakthrough volume measuring system

Calibration gas mixture passes through a sorbent tube with a constant flow rate between 20 and 200 ml/min. Flow rate should be selected in this range appropriate for the sample rate intended. Note the time when gas initiate entering the system. After passing through the sorbent tube, analytes goes to the detector and a signal is generated. Measurements should be continued until plateau appears on the chromatogram. Determine time that was need to get 5 % of maximum signal (Figure 3.7).

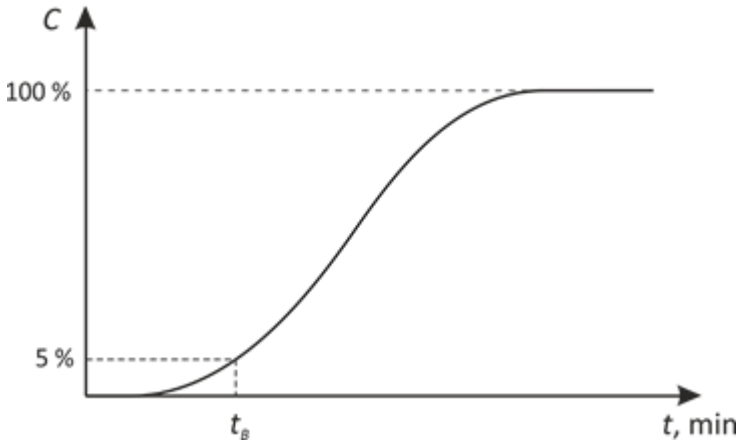


Figure 3.7 – Determination of breakthrough volume

Calculate breakthrough volume V_B (L) according to the following formula:

$$V_B = Ft_B$$

Where:

F – gas flow rate, L/min;

t_B – time needed to get 5 % of maximum signal, min.

Typically, dead volume of sampling line is significantly less than breakthrough volume. If this is not the case, dead volume can be determined by repeated measurement using an empty sample tube. In this case breakthrough volume result needs to be corrected.

Retention volume – gas volume needed to get a maximum peak during elution of compound from the sample tube.

Diagram of system used to determine a retention volume is shown in the Figure 3.8.

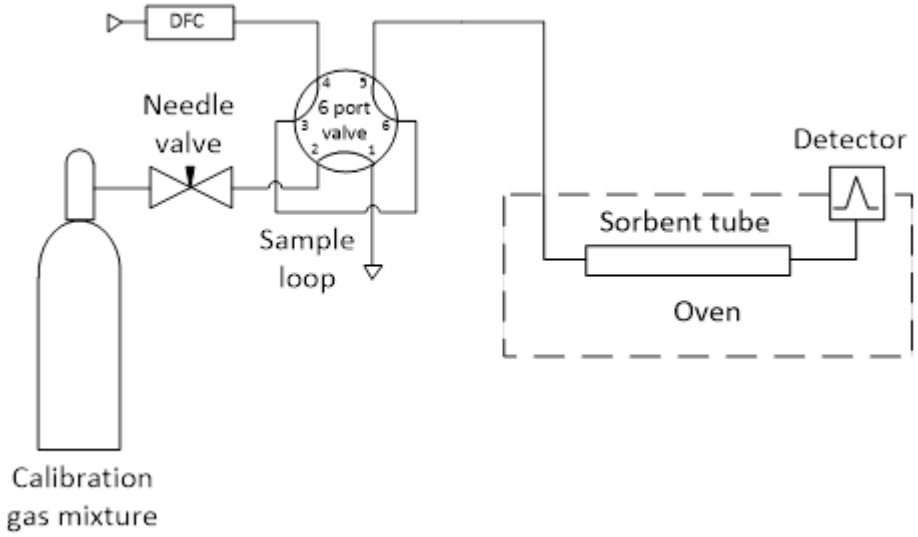


Figure 3.8 – Diagram for retention volume measuring system

The sorbent tube is connected between the sampling valve and the detector. The gas flow regulator ensures a constant carrier gas flow through the tube. To ensure quick analysis, the sorbent tube should be placed into the oven. Using sampling valve, inject a certain volume of calibration gas mixture into the sample tube and determine time needed to get a maximum peak (Figure 3.9). Measurements should be carried out at different temperatures in such a manner as to get retention time between 2 and 20 minutes.

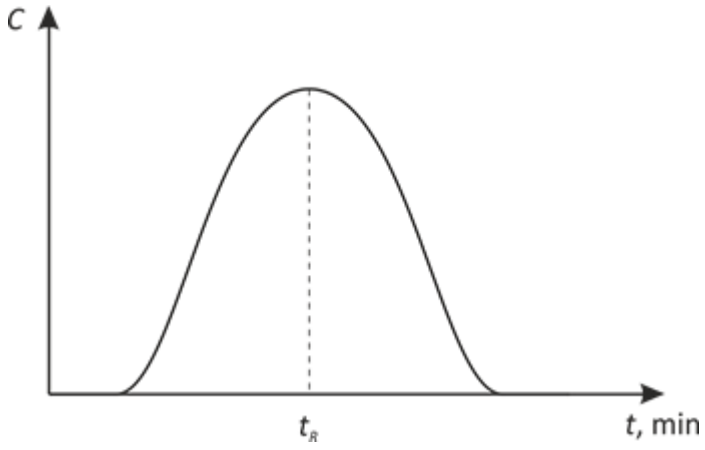


Figure 3.9 – Determination of retention volume

Calculate retention volume V_R (L) according to the following formula:

$$V_R = Ft_R$$

Where:

F – carrier gas flow rate, L/min;

t_R – retention time, min.

To get a retention volume for at room temperature, you need to draw a graph showing retention volume vs. temperature and extrapolate it to 20 °C (Figure 3.10).

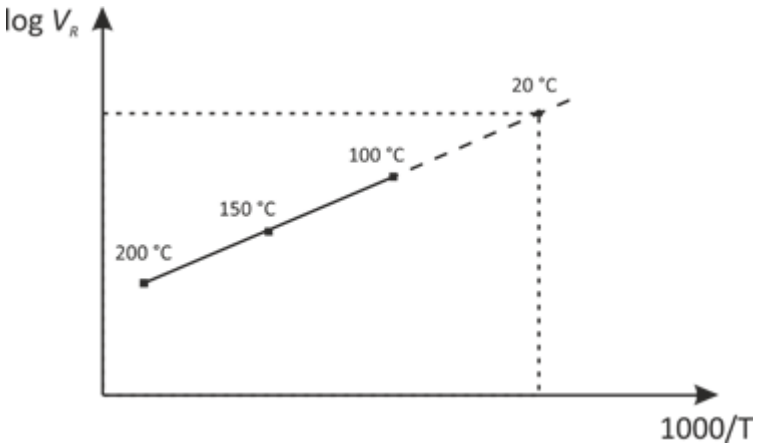


Figure 3.10 – Extrapolation of retention volume to room temperature

The breakthrough volume and the retention volume are unique for each sorbate-sorbent pair and depends on ambient temperature. Typically, the breakthrough volume and the retention volume decrease by 2 times when temperature increases by 10 °C. This should be considered for warm air sampling.

To have a certain margin in order to ensure reliable measurement, "safe sampling volume" term is used. This term refers to a recommended maximum volume of sample. The safe sampling volume must not exceed 70 % of breakthrough volume or 50 % of retention volume. The safe sampling volume is determined in liters (L) or liters of pumped air per gram of adsorbent (L/g). Safe sampling volume values for different organic compounds and certain adsorbents can be found in literature[1]. Before using reference values, it is recommended to check them.

[1]ISO 16017-1:2000 Indoor, ambient and workplace air – Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography – Part 1: Pumped sampling.

ISO 16000-6:2011 Indoor air – Part 6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA sorbent, thermal desorption and gas chromatography using MS or MS-FID.

ASTM Method D 6196-15 Standard Practice for Selection of Sorbents, Sampling, and Thermal Desorption Analysis Procedures for Volatile Organic Compounds in Air.

MHDS 72 UK Health and Safety Executive. Method for the Determination of Hazardous Substances. Volatile organic compounds in air – Laboratory method using pumped solid sorbent tubes, thermal desorption and gas chromatography.

Certain adsorbents, for example Carbosieve® S-III or Carboxen® 1000, also may hold a certain amount of moisture. Therefore, when sampling in high relative humidity conditions (> 90 %), decrease sampling volume by 10 times.

3.8 Sample tube storage

For storage of sample tubes use the set of caps 4.069.005 containing two caps 6.433.043. The cap 6.433.043 comprises of plug 8.632.092, ferrule 8.658.061 and nut 8.930.172-02 (Figure 26).

The cap 6.433.043 can be installed in the following order:

- Place the ferrule 8.658.061 into the cap 8.632.092.
- Screw the nut 8.930.172-02 onto the cap 8.632.092, but do not tighten it.
- Push the sample tube into the nut 8.930.172-02 against stop.
- Tighten the nut 8.930.172-02 by hand until the sample tube can not freely move.

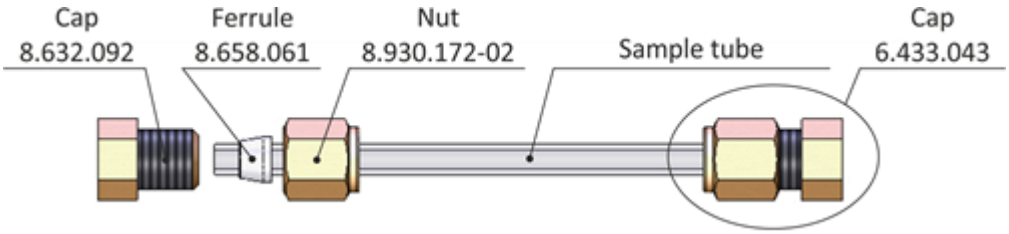


Figure 3.11 – Mounting caps on the sample tube

Never use tools to tighten caps during sample tube sealing. This could lead to ferrule or sample tube damage.

For storage of glass tubes can be used the container 6.087.021 (Figure 3.12).

To put the sample tube into the container 6.087.021:

- Screw the nut 8.930.134.
- Insert the tube into the container.
- Tighten the nut 8.930.134 by hand.

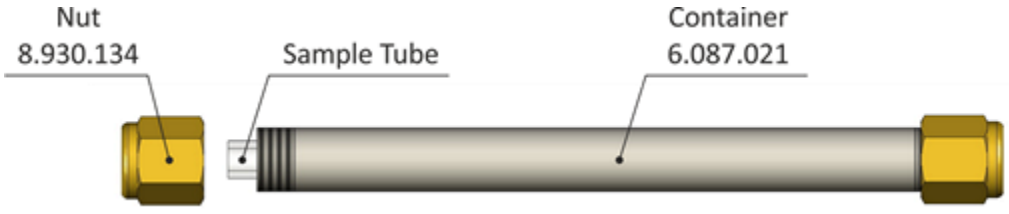


Figure 3.12 – Placing the sample tube into the container

If analysis will not be carried out within 8 hours after sampling, store sample tubes in clean sealed container made of glass or metal. To protect sample tube against pollution, place into container a clean white cotton bag packed with activated carbon.

The container with tubes may be stored in a refrigerator at temperature between 4 and 6 °C provided that there are not organic compounds in a refrigerator.

In case of temperature change, re-tighten caps of the sample tubes to ensure that they are sealed.

During long term storage of multiple beds tubes, semi-volatile compounds may migrate from the weak sorbent to the strong one. Therefore, during analysis this could lead to incomplete desorption of semi-volatile compounds.

3.9 Analysis of solid samples

The thermal desorption method can be used to analyze solid samples, for example, medical products, polymers, food products etc.

Complete extraction of volatile components from solid samples can be achieved for highly homogeneous systems only. In all other cases, the thermal desorption method will only give information about composition that can be used, for example, to compare several samples or get product profile (fingerprint).

Sampling solids is shown in the Figure 3.13. The sample is placed into a central part of the sample tube and fixed with two glass wool plugs.

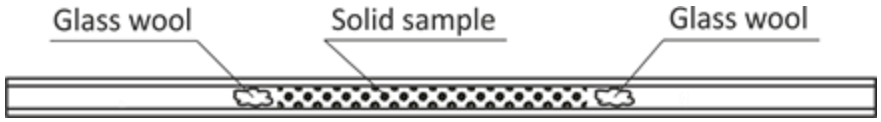


Figure 3.13 – Sampling solids

When proceeding with analysis of solid samples containing highly boiling compounds (e.g., resins), place into tube a little amount of sample. This will help to avoid contamination of the system. Before placing the solid sample, you can place a small adsorbent bed that will pass volatile analytes but trap compounds such as resins or fats (Figure 3.14). Typically, Tenax® TA is a good adsorbent for these applications.

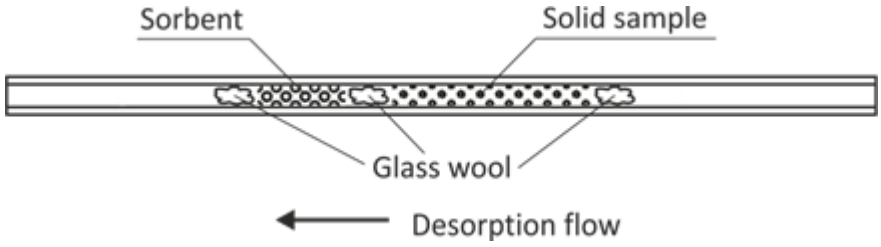


Figure 3.14 – Placing a sorbent after the soil sample

3.10 Setting operation parameters

This section contains guidance on setting operation parameters of the thermal desorber. Parameter selection should be carried out in accordance with the method of analysis used.

3.10.1 Desorption temperature

Desorption temperature should be selected in such a manner as to ensure complete extraction of components from the adsorbent. On the one hand, the temperature should be as high as possible and it is limited of adsorbent operating temperature (Table 3.1). However, when temperature is close to maximum operating temperature of the adsorbent, it begins to decompose and different contaminants appear as a result. Therefore, it is recommended to avoid setting too high desorption temperature.

The recommended maximum desorption temperatures for different adsorbents are shown in the Table 3.5.

For desorption of compounds from sample tubes packed with different adsorbents, select desorption temperature considering the adsorbent with minimum operating temperature.

When choosing desorption temperature, also consider possible decomposition of analytes at that temperature.

Table 3.5 – Recommended maximum desorption temperatures

Sorbent	**Maximum desorption temperature, °C**
Tenax® TA	300
Tenax® GR	300
Porapak™ Q	225
Porapak™ N	180
Carbopack™ B	325
Carbopack™ C	325
Carbosieve® S-III	325
Carboxen® 1000	325

To check that compounds were desorbed from the adsorbent completely (desorption efficiency) carry out a subsequent analysis of the sample tube. After repeated desorption peak responses should not exceed level specified in the analysis standard. Another may to check a desorption efficiency is comparison of peak responses during a thermal desorption and a direct injection into the GC injector.

If components can not be completely desorbed at maximum operating temperature of the adsorbent, increase desorption time or use another adsorbent which is weaker or has a higher operating temperature.

3.10.2 Purge gas flow rate

The purge gas flow rate should be selected that compounds are completely desorbed from the sample tube within a minimum time. On the other hand, too high purge gas flow rate may lead to breakthrough of compounds through the trap. So, optimum purge gas flow rate is between 30 and 50 ml/min.

If helium is used for the purge gas, at a flow rate more then 50 ml/min the trap may not reach the low temperature.

3.10.3 Desorption time

The desorption time should be sufficient for the complete desorption of components. Depending on the desorption temperature and the purge gas flow rate, the desorption time may be selected between 5 and 20 minutes. It is necessary to set the minimum time to improve the productivity of the thermal desorber.

3.10.4 Focusing components in the trap

As the trap refocus compounds at low temperature and low gas volume passes through it, typically the trap can be packed with weaker sorbent than that used in the sample tube.

Table 3.6 shows recommendations on packing trap depending on sorbent in the sample tube.

Table 3.6 – Recommendations on packing trap

Sorbent in tube	**Sorbent in trap**
Tenax® TA	Tenax® TA
Tenax® GR	Tenax® GR
Porapak™ Q	Porapak™ Q or Carbopack™ B / Carbosieve® S-III
Porapak™ N	Porapak™ N or Carbopack™ B / Carbosieve® S-III
Carbopack™ B	Carbopack™ B or Tenax® GR
Carbopack™ C	Carbopack™ C or Tenax® TA
Carbosieve® S-III	Carbosieve S-III or Carbopack™ B / Carbosieve® S-III
Carboxen 1000	Carboxen® 1000 or Carbopack™ B / Carboxen® 1000
Tenax® TA / Carbopack™ B	Tenax® TA or Tenax® TA / Carbopack™ B
Tenax® TA / Carbosieve® S-III	Tenax® TA / Carbosieve® S-III
Tenax® TA / Carboxen® 1000	Tenax® TA / Carboxen® 1000
Tenax® GR / Carbopack™ B	Tenax® GR or Tenax® GR / Carbopack™ B

Sorbent in tube	Sorbent in trap
Tenax® GR / Carbosieve® S-III	Tenax® GR / Carbosieve® S-III
Tenax® TA / Carboxen® 1000	Tenax® GR / Carboxen® 1000
Carbopack™ B / Carbosieve® S-III	Carbopack™ B / Carbosieve® S-III
Carbopack™ B / Carboxen® 1000	Carbopack™ B / Carboxen® 1000
Tenax® TA / Carbopack™ B / Carbosieve® S-III	Tenax® TA / Carbopack™ B / Carbosieve® S-III
Tenax TA / Carbopack™ B / Carboxen 1000	Tenax® TA / Carbopack™ B / и Carboxen® 1000
Tenax® GR / Carbopack™ B / Carbosieve® S-III	Tenax® GR / Carbopack™ B / и Carbosieve® S-III
Tenax® GR / Carbopack™ B / Carboxen® 1000	Tenax® GR / Carbopack™ B / Carboxen® 1000
Carbopack™ B / Carbosieve® S-III / Carboxen® 1000	Carbopack™ B / Carbosieve® S-III / Carboxen® 1000
Carbopack™ C / Carbopack™ B / Carbosieve® S-III	Carbopack™ C / Carbopack™ B / Carbosieve® S-III
Carbopack™ C / Carbopack™ B / Carboxen® 1000	Carbopack™ C / Carbopack™ B / Carboxen® 1000

The trap should be packed with adsorbent in the same way as a sample tube. The sorbent bed length must be 40 mm. When packing trap with several sorbents, the weakest one must be located closer to narrowing part of the trap. The packed trap is shown in the Figure 3.15.

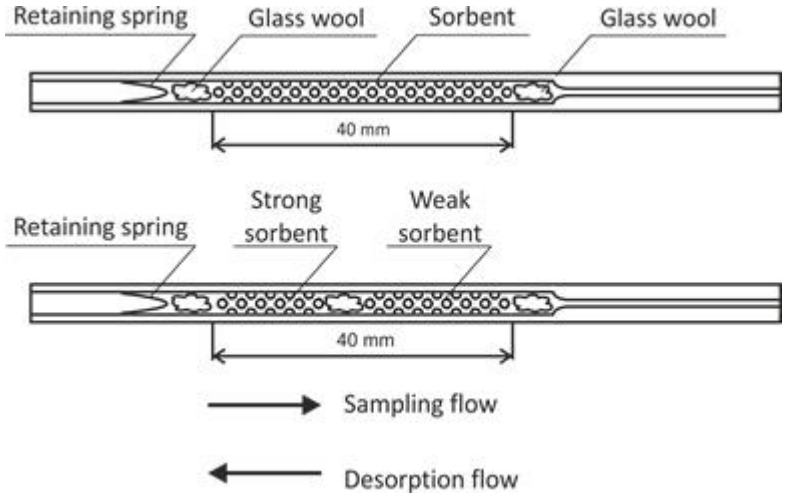


Figure 3.15 –Packing focusing traps

During desorption from the trap, gas flow in reverse direction that during sorption. Reverse gas flow prevents contact low volatile compounds with a strong adsorbent as this could lead to their irreversible sorption.

3.10.5 Trap low temperature

The trap low temperature should be selected in such a manner as to prevent breakthrough analytes. You can check whether components could break through the trap in the following way. Inject a standard mixture directly into the GC injector and through the trap in the thermal desorber. If response during direct analysis exceeds that during analysis in the thermal desorber, this means that sample cannot be completely focus in the trap. In this case it is necessary to decrease the trap temperature. If decrease temperature down to –20 °C cannot solve the problem, use a stronger adsorbent in the trap.

In the analysis of humid samples is possible an ice formation in the trap and its clogging. In this case, the measured flow rate of purge gas would be 0 ml/min. To prevent clogging the trap in the humid samples analysis, it is recommended to set the trap temperature above 4 °C.

3.10.6 Trap high temperature

The trap high temperature should be selected in such a manner as to ensure complete desorption. You can check desorption of compounds from trap in the same way as for the sample tube. If peak responses during next desorption are not negligible comparing to responses obtained during analysis, then increase the trap high temperature.

The trap high temperature must not exceed maximum operating temperature of the sorbent (Table 3.1).

3.10.7 Heating rate

Heating rate should ensure rapid desorption of components from the sorbent and their transfer into a GC column. For analysis of volatile organic compounds is set higher heating rate.

For analysis of thermally labile analytes which may decompose at rapid temperature increase is set lower heating rate.

3.10.8 Heating time

Typically, for complete desorption of components from the trap needs 1-2 minutes. If this time is insufficient, for example, in case of low heating rate, increase heating time in such a way that during next analysis chromatogram shows no peaks remained from previous analysis.

3.10.9 Tube conditioning

The tube conditioning is used to remove volatile contaminants from the sample tube before next sampling.

Typically, the conditioning temperature should be set by 10-20 °C above the desorption temperature. However, it must not exceed the maximum operation temperature of the sorbent.

For recommended maximum temperatures for tube conditioning, see the Table 3.3.

To make conditioning faster, set purge gas flow rate to approx. 100 ml/min or approx. 50 ml/min for multiple beds tubes.

The tube conditioning time should be selected in such a way as to ensure that during next analysis contaminant response cannot exceed 10 % of minimum responses of compounds during analysis. Typically, the time conditioning is set between 10 and 20 minutes.

3.10.10 Valve temperature

Valve heating is needed to prevent condensation of analytes. The valve temperature depends on analytes and typically is set between 150 and 200 °C.

3.10.11 Transfer line temperature

The transfer line temperature should be selected as to prevent condensation of analytes. To get best repeatable results, the transfer line temperature should be set by 5 – 10 °C above valve temperature.

3.10.12 Carrier gas flow rate

To transfer sample from the thermal desorber to the GC, carrier gas flow rate should be set between 5 and 15 ml/min. For capillary columns with inner diameter less 0.32 mm and carrier gas flow rate through the column between 0.5 and 2 ml/min should be set minimum split in the injector (between 1:1 and 1:10).

3.10.13 Leak test

The leak test value should be set in such a manner as to ensure that pressure drop in the sample tube during the leak test before desorption step will be checked. This value depends on adsorbent and packing density of the sample tube.

Typically, the leak test is set 1 kPa.

3.11 Calibration

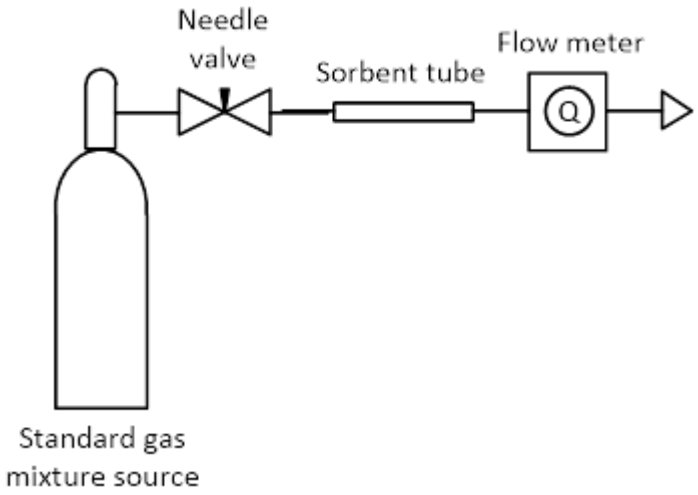
The calibration must be as close as possible to real analysis conditions. To get accurate results, the standards must injected in the sample tube and completely repeat all analysis steps.

More frequently calibration is carried out using standard gas mixtures or liquid mixtures.

3.11.1 Calibration with standard gas mixtures

Calibration gas mixtures should be prepared as specified in standards ISO 6141 and ISO 6145. Depending on component subject to analysis (workplace air, indoor air, ambient air etc.), concentration of analytes in calibration mixtures may be between 100 µg/m^3 and 10 mg/m^3. I However, it should correspond to the expected average concentration in the samples.

For calibration, sorbent tubes should be prepared by sampling through them a known volume of standard gas mixture, for example 100 ml, 200 ml, 400 ml, 1 l, 2 l, 4 l or 10 l. For sorbent tube connection diagram, see the Figure 3.16. The mixture volume must not exceed the breakthrough volume.



S – Standard gas mixture source; V – Needle valve; T – Sorbent tube; F – Flow meter.

Figure 3.16 – Connection the sorbent tube to the standard gas mixture blends

If concentration in the standard gas mixture significantly exceeds expected concentrations in the sample, you can use the sampling valve with the loop to inject into the sample tube gas mixture volume from 0.5 to 10 ml. The sample must be carried from the loop into the sample tube by inert gas volume of which must exceed the loop volume more then 20 times. The inert gas supply may be provided using the restrictor 5.150.015-02, which provides flow rate approx. 20 ml/min at the pressure 400 kPa. For principal diagram of device used to carry sample to the sorbent tube using the sampling valve, see the Figure 3.17.

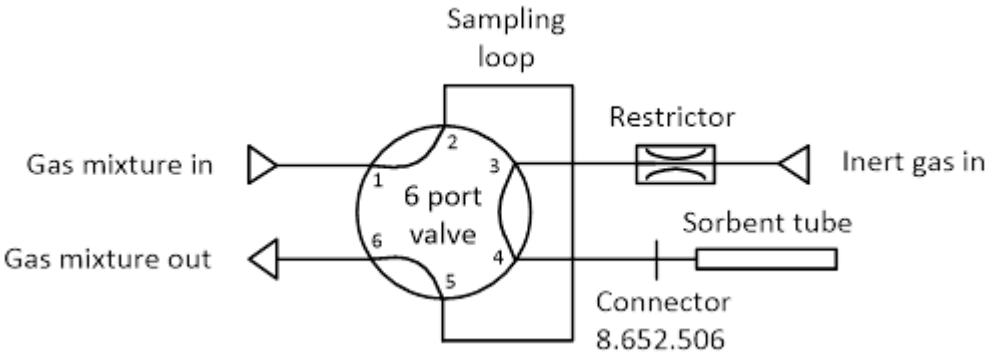


Figure 3.17 – Injection gas mixture in the sorbent tube

3.11.2 Calibration with liquid mixtures

For calibration with liquid mixtures, consider that RSD will be higher than for calibration with gas mixtures as injection sample with syringe leads to significant error.

Before calibration calculate concentration in the liquid calibration mixture. Mass of analytes must correspond to mass during sampling.

There is the calculation of the compound's concentration in the calibration mixture.

- Expected concentration in air is 10 µg/m^3.
- During sampling, 1 liter air is pumped.
- 1 liter air contains 10 ng of the compound.
- During calibration, 1 µL of liquid mixture will be injected to the sample tube.
- In the calibration mixture concentration should be 10 ng/µL or 10 µg/mL.

For liquid standard preparation use solvent type "standard for GC", that must be checked to ensure that there are no contaminants. Before selecting a solvent, ensure that cannot elute together with analytes. It is recommended to use more volatile solvent that analytes. In this case, before analysis it can be purge from the sorbent tube. The most preferable solvent is methanol.

Volume of inert gas for purging solvents from a sorbent tube Tenax® TA is shown in the Table 3.7.

Table 3.7 – Volume of inert gas for purging solvents

Solvent	**Gas volume, L**
Acetone	1.2
n-Hexane	6.4
Dichloromethane	0.9
1,1-Dichloroethylene	0.9
Methanol	0.1
Methyl ethyl ketone	6.4
n-Pentane	1.0
Chloroform	3.8
Ethanol	0.4
Ethyl acetate	7.2

A calibration with liquid mixtures can be carried out in two ways: injection solution via injector or injection solution directly into the sorbent tube.

Injection solution via inlet

The sorbent tube should be connected to the packed GC inlet (Figure 3.18). For the capillary GC injector split must be plugged or set flow rate 0 ml/min.

- Set the injector temperature a little lower than a solvent boiling temperature.

- Set the carrier gas flow rate to between 50 and 100 ml/min.
- Using a syringe inject 1-5 µl of calibration mixture via injector membrane.
- When specified time expires, disconnect the tube and completely seal it.

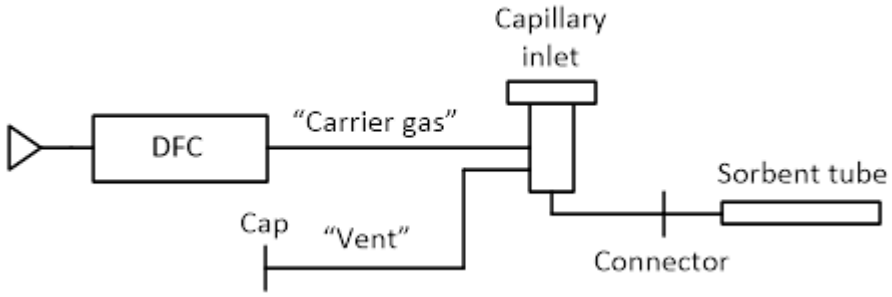


Figure 3.18 – Injection solution via injector

Injection solution directly into the sorbent tube

Using a syringe inject 1-5 µl of calibration mixture into the sample tube from the sampling side (no tag from this side). The liquid solution must be injected into the glass wool (Figure 3.19).

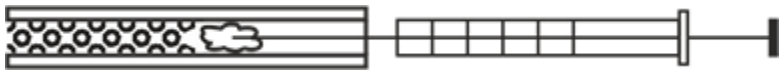


Figure 3.19 – Injection solution into the sorbent tube

After injection purge the sorbent tube with inert gas to simulate of analysis conditions. The gas volume should not exceed the breakthrough volume.

To liquid solution injection can be used the injection unit 214.5.885.023 (Figure 3.20).

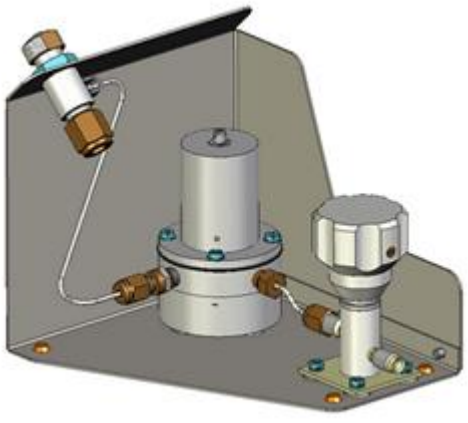


Figure 3.20 –Unit 214.5.885.023 for liquid solution injection into the sorbent tube

Instead of the unit 214.5.885.023 for tube purging you can provide purging by the carrier gas, which is used to supply the chromatograph. For this purpose, a tee and pneumatic restrictor 5.150.015-02 are installed before the inlet to the gas chromatograph. For connection to the sorption tube use

adapter fitting 8.652.506. The connection diagram of the sorption tube is shown in the figure below. If calibration is not carried out, the connection can be closed with a plug.

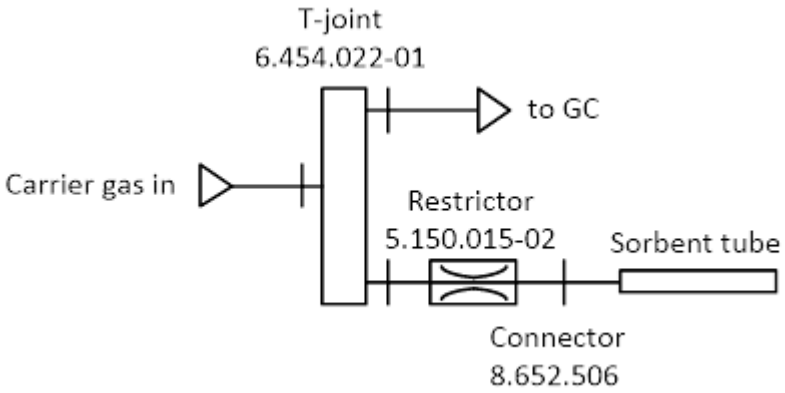


Figure 3.21 – Connection diagram for sorbent tube purging

3.12 General recommendations

For sample tube marking avoid using paints and markers containing solvents. Also, avoid using stickers.

To eliminate contamination of the system is prohibited to wash the input tubing and gas tubes in the thermal desorber with organic solvents.

During long term storage the sample tube caps may sorb pollutants from an ambient air. Also, caps that were used for sample tubes sealing, may keep contaminants. To clean caps 8.632.091 and ferrules 8.658.061 place them to ultrasonic cleaner for 10-15 minutes. After that carefully wash them with distilled water and dry at temperature 60 °C for 20 minutes to completely remove residual solvent.

Before analysis, it is recommended to make two blank analyses: with laboratory blank tube and analysis blank tube. Laboratory blank tubes should be prepared and stored with sampling tubes. This analysis eliminates errors associated with conditioning tubes and their storage in the laboratory. Also, they can be used for monitoring adsorbent stability. Blank tubes analysis should be prepared and transferred to a sampling place together with sampling tubes. By sampling caps are removed from sorbent tubes and immediately put back. This procedure eliminates the errors associated with sample storage and transportation.

4 Troubleshooting

During operation following problems may be encountered:

- Poor reproducibility of parallel measurement results.
- Broadening or trailing peaks.
- False peaks.
- No peaks on chromatogram.

When any failure is revealed, check that method of thermal desorber compliances analysis requirements. For principals of method development and parameter selection see section 3.

4.1 Poor reproducibility

Reproducibility of measurement results should be checked as specified in the Section 2.4.

All causes that affect reproducibility may be divided into two groups – analytic (systematic) and hardware. To reveal causes that lead to no RSD, at first check analytic requirements and then try to find hardware causes.

It should be mentioned that normal reproducibility of analysis results should meet values specified by analysis method rather than RSD specified in technical specifications.

4.1.1 Analytical requirements

Volume of sample taken to the sample tube should be accurately measured and continuously repeated in all analyses.

If this requirement is met, but reproducibility of analysis results continues to be poor, then check hardware.

4.1.2 Hardware problems

- Poor sealing of the sample tube or the trap.
- Poor sealing of gas tubing.
- Poor sealing of needle assembly, damaged needle.
- Faulty GC.

4.1.3 Checking sealing of the sample tube or the trap

Poor sealing of the sample tube or the trap may affect to peak height or may lead to situation when there are no peaks on the chromatogram.

Before desorption, the sample tube and the trap automatically pass leak test. Leak test is based on pressure drop in the gas line. Permissible pressure drop value may be set in Configuration menu. When poor sealing is detected, display shows "Leak test failed" warning.

Actions:

- Replace ferrule in the tube oven as specified in Section 3.7.
- Replace O-rings of the trap as specified in Section 7.3.3.
- Check sealing of tubing as specified in Section 7.3.2.

4.1.4 Checking sealing of tubing

Proceed as specified in Section 5.2.

4.1.5 Checking sealing of the needle

If needle has poor sealing, this may lead to decrease of peak height.

Actions:

- Place rubber plug to the transfer line needle.
- Apply inert gas pressure between 0.4 and 0.44 MPa to "Carrier inlet" connector.
- Turn on the thermal desorber.
- Set carrier gas flow rate to 100 ml/min.
- Place needle fitted with piece of rubber into a water. If you see gas bubbles, then eliminate leakage by tightening nut 8.930.161 or replace damaged needle as specified in Section 5.4.3.

4.1.6 Checking GC performance

The GC performance check includes measuring RMS by injecting test mixture. The composition of test mixture should be select depending on actual analysis conditions.

4.2 Broadening or trailing peaks

Peak broadening may occur due to the following reasons:

- Liner with large inner diameter is installed in the injector. Install liner 7.352.066 to injector.
- Insufficient carrier gas flow during desorption of components from the trap. Set carrier gas flow rate according to recommendations in Section 3.10.12.
- Trap packed a strong adsorbent. Replace it to weak adsorbent according to recommendations in Section 3.10.4.
- During desorption too many waters or solvent is accumulated on the trap. As a result, water or solvent evaporates rapidly due to high trap heating rate and this leads to a wide chromatographic band. Increase the trap low temperature to minimize water or solvent effect or set slow heating rate (from 500 °C/min to 1000 °C/min).

- Chromatographic column overload. The column capacity depends on thickness of stationary phase and refers to a value between 20 and 1000 ng. Increase split in the injector.
- Aging of chromatographic column. Replace chromatographic column with a new one.

Trailing peaks of volatile components is an indication of the trap expiry. Replace the trap according to Section 5.3.3.

4.3 False peaks

When false peaks appear, consider that all adsorbents during desorption evolve contaminants and mass of these contaminants may be of several nanograms. Porous polymer adsorbents (e.g. Porapak™) have the highest noise level (between 5 and 50 ng), Tenax® has medium noise (between 0.1 and 1 ng). Minimum noise level feature carbon adsorbents like Carbopack™, Carbosieve®, Carboxen® (between 5 and 50 pg).

False peaks having the same retention time as peaks of analytes may appear due to incomplete desorption of compounds from the sorbent tube or the trap. Also, compounds may accumulate in gas channels. The most probable reason of that problem is that method parameters were set improperly.

False peaks having retention time that differs from that of analytes may appear due to contaminants in gas channels as a result of using dirty purge gas or high desorption temperature leading to adsorbent decomposition.

To reveal reason of dirt, perform series analyses:

- Blank analysis on the GC when the thermal desorber is turn off. If false peaks exist, locate the problem in the GC.
- Blank analysis with empty sample tube. If chromatogram demonstrates no false peaks, this means that problem is in incomplete desorption of analytes from adsorbent or poor conditioning of the sample tubes after previous analysis. Depending on analysis method, select proper desorption temperature, purge gas flow rate and desorption time in such a manner as to ensure complete desorption of compounds.
- Blank analysis with trap low temperature 30 °C. If chromatogram demonstrates no false peaks, this means that purge gas is not clean as needed. Use purge gas with purity of 99.999 %, replace filters in purge gas lines.
- Blank analysis with empty trap. If chromatogram demonstrates no false peaks, this means that problem is in incomplete desorption of components from the trap. Depending on analysis method, select proper temperature, carrier gas flow rate and heating time as to ensure complete desorption of compounds.

If blank analysis with empty sample tube and trap demonstrates the presence of dirt, possible reasons are as follow:

- Low temperature of valve of transfer line. Increase temperature of valve or transfer line.
- Contamination in needle of the transfer line. Clean the needle or replace as specified in Section 5.3.4.
- Contamination in valve channels. Accurately purge valve channels withy clean inert gas.
- Contamination in carrier gas or purge gas tubing. Accurately purge tunings by clean inert gas.

- Contamination in tubing of transfer line. Accurately purge transfer line by clean inert gas. If the transfer line has hard removable contaminations is allowed to wash it by methylene chloride, toluene, ethanol or ethyl acetate.

Before transfer line washing contact manufacturer to obtain appropriate recommendations.

4.4 No peaks on the chromatogram

Possible reasons of this problem:

- Poor sealing of carrier gas tubing. Check the leakiness as specified in Section 5.2.
- Poor sealing of sample tube or trap. Check the leakiness as specified in Section 5.2.
- If carrier gas flow rate does not reach the specified value, the problem may be in the valve which cannot rotate to the final position and impairs flow in gas channel. To eliminate this problem, contact manufacturer.

5 Maintenance

5.1 Maintenance types

The thermal desorber requires two types of maintenance:

- Routine maintenance.
- Periodic maintenance.

Current maintenance may be carried out by customer.

Periodic maintenance may be carried out by customer or service engineer.

The recommended time interval for both maintenance types should be considered based on 10–20 analyses per day.

Time intervals of maintenance may vary depending on:

- Intensity of thermal desorber usage.
- Working temperatures of the valve, the trap, the tube oven.
- Types of samples.

Maintenance procedures also should be carried out when any problems are revealed.

5.2 Routine maintenance

For routine maintenance procedures see the Table 5.1.

Table 5.1 – Routine maintenance

Procedure	**Periodicity**
General procedures: Checking cleanness of transfer line needle hole. Checking the stability of specified gas flow rates and temperatures.	Daily
Routine procedures: Checking ferrules of the sample tube.	Daily

In most cases, general procedures are non-objective and their validity depends on operator experience. However, in combination with the evaluated technical parameters of the thermal desorber, together with the chromatograph, these evaluations can be taken into account in subsequent troubleshooting actions.

The stability of maintaining the set gas flow rates and temperatures can be assessed by measured values on the thermal desorber indicator.

Cleanness of transfer line needle hole should be examined visually by installing the needle into the GC injector. Possible dirt, for example pieces of membrane, can cause of "memory effect".

Actions:

- When rubber residuals are revealed in the needle hole, accurately remove them with a needle with sharp end. Alternatively, you can use a thin wire.
- When rubber residuals are revealed inside the needle, remove it, accurately clean it and re-install as specified in the Section 5.3.4.

5.3 Periodic maintenance

For periodic maintenance procedures see the Table 5.2.

Table 5.2 – Periodic maintenance

Procedure	**Periodicity**
Checking of the injector membrane	Monthly
Leak testing	Once in half-year
Replacing of the sorption tube	Once a year or after 100 tests and in case of malfunctions
Replacing the sorption tube O-rings	Every 500 tests or in case of leaks
Replacing the trap	Yearly or after 200 analyses
Replacing the transfer line needle	On demand

Checking of the inlet septum

Inlet septum is worn out by installation of the transfer line in the injector.



Before septum replacing cool the injector to avoid getting burned.

Actions:

To replace the septum, remove the transfer line from the inlet, remove the septum nut. Install a new septum and re-assemble in reverse order.

Leak testing

Leak testing is performed for two channels: Carrier gas and Purge gas.

Leak testing for Carrier gas channel:

- Place a piece of rubber (e.g. septum) to the transfer line needle.
- Set carrier gas pressure between 0.4 and 0.44 MPa.
- Turn on the thermal desorber.
- The valve switch is in the "Desorption" position
- Set carrier gas flow rate to 100 ml/min.

- After 1 minute, note measured carrier gas flow rate. Acceptable value must be less than 1 ml/min. If this leakage value is exceeded, locate the failed area by applying ethanol to connectors. When failed area is found, eliminate leakage.

Leak testing for Purge gas channel:

- Place the cap 6.432.002 to Vent connector.
- Place the empty sample tube to the oven.
- Set purge gas pressure between 0.15 and 0.2 MPa.
- Turn on the thermal desorber.
- The valve switch is in the "Desorption" position, solenoid valves 1 and 2 are open.
- Set purge gas flow rate to 100 ml/min.
- After 1 minute, note measured purge gas flow rate. Acceptable value must be less than 1 ml/min. If this leakage value is exceeded, locate the failed area by applying ethanol to connectors. When failed area is found, eliminate leakage.

To avoid contamination of the system, it is prohibited to use soap solutions for leak test.

When tightening fittings, avoid applying to much force exceeding values shown in Section 1.4.

If you cannot locate problem area by using ethanol, it can be determined by installing plugs to a certain portions of gas lines.

5.3.1 Replacing the sorbent tube

The sorbent tube shall be replaced when the type of sorbent used is changed or its service life expires.

The procedure for packing the sorbent tube with sorbent is described in section 3.5.

5.3.2 Replacing the sorption tube O-rings

The sealing rings of the sorption tube must be replaced if they show visible signs of deformation or if the sorption tube seal is loose.



The rings are replaced after the thermostats of the valve and sorption tube have cooled to room temperature.

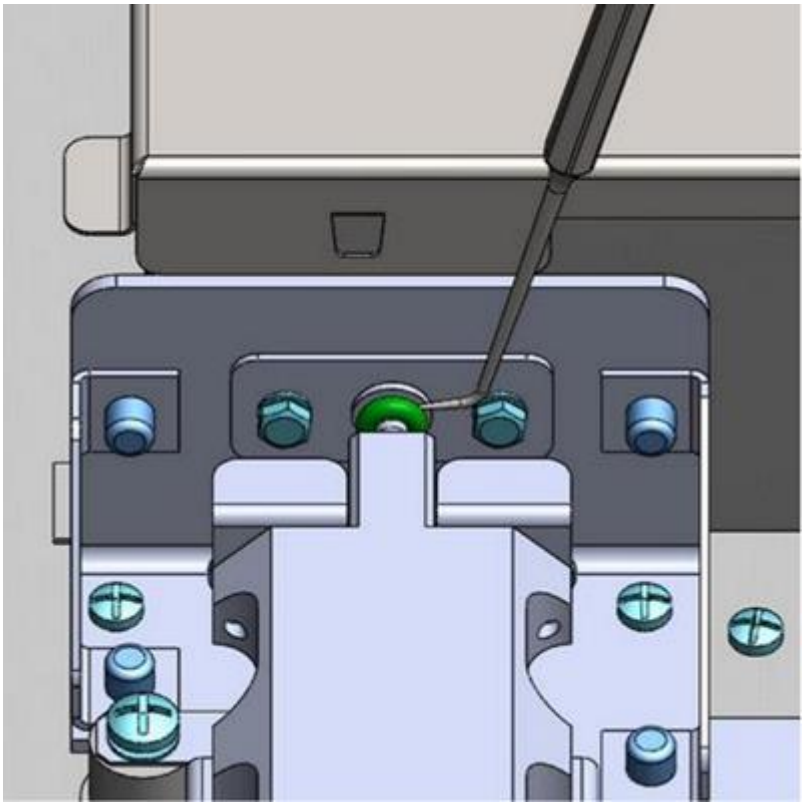
O-rings are located at the rear of the sorption tube thermostat and in the bayonet.

Install only rings 8.685.177 to seal the sorption tube.

Replacing the ring in the back of the thermostat

Actions:

- Remove the thermal desorber top cover.
- Use hook 6.461.001 to remove o-ring.



- Clean mechanical particles from the ring installation site with a cotton swab.
- Carefully install the new ring by hand.

Replacing the bayonet ring

Actions:

- Disconnect the sorption tube seal bayonet on the front panel of the instrument.
- Hook the ring with hook 6.461.001 and remove it from the flange.



- Clean mechanical particles from the ring installation site with a cotton swab.
- Carefully install the new ring by hand.

- Use hook 6.461.001 only to remove the rings. Install new rings by hand, without using any tools.

5.3.3 Replacing the trap

The trap should be replaced in case of changing adsorbent type or when its service life expired.



The valve and the trap may be hot. Allow 30 minutes for cooling these parts.

Actions:

Tighten nuts 8.936.078 by hand and avoid using tools as it can damage the trap.

- Remove the trap cover.
- Unscrew nuts 8.936.078.
- Remove rings 8.683.032.
- Take out the trap.
- Install a new trap with a narrow part towards valve.
- Install rings 8.683.032.
- Screw nuts 8.936.078.
- Install the trap cover.

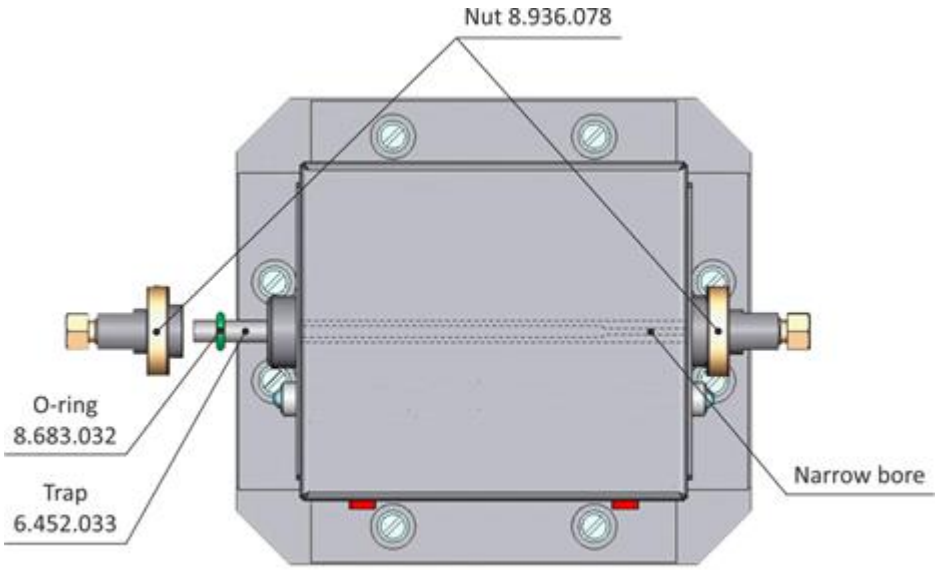


Figure 5.1 – Replacing the trap

For procedure of trap packing see Section 3.10.4.

5.3.4 Replacing the transfer line needle

The transfer line needle should be replaced when it becomes dirty or damaged.

Actions:

- Unscrew the nut 8.930.111.
- Remove the current needle.
- Place a ferrule 8.658.017 onto a new needle
- Tighten the nut 8.930.111.

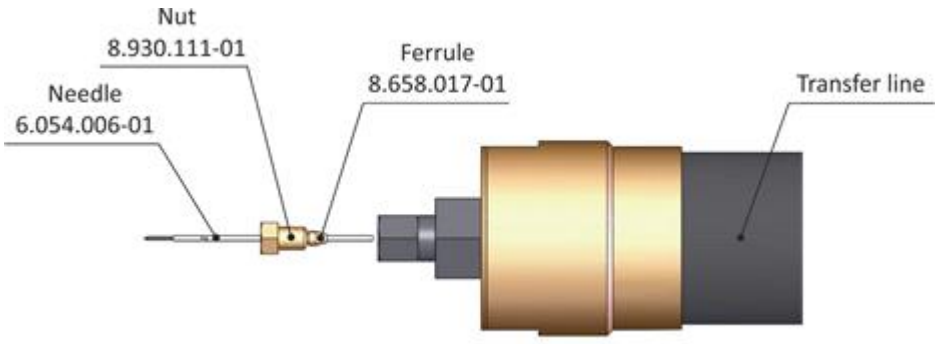


Figure 5.2– Needle installation

After needle installation perform the leak test as specified in the Section 5.2.

6 Transportation and storage

The thermal desorber in manufacturer package can be shipped over any distance by any transport except for non-pressurized aircraft compartments and open decks of sea transport. Ensure adequate protection of shipping container from atmospheric precipitations.

Shipping requirements:

- ambient temperature between – 50 and 50 °C;
- maximum RH 98 % at 35 °C;
- avoid any dust or aggressive vapors in air.

Shipping containers should be placed into transport in such a way that prevents them from mechanical shocks. During loading operations, avoid any container drops or mechanical damage. Also, protect them against precipitations.

The packaged sampler should be stored in closed warehouse meeting the conditions 2 per GOST 15150-69:

- ambient temperature between – 30 and 40 °C;
- maximum RH 98 % at 25 °C.

Avoid any dust or aggressive vapors in air.

Packages may be stored in stacks (three layers maximum).

Before using thermal desorber taken from warehouse in cold periods, leave it at normal conditions for 4 hours minimum.

7 Manufacturer warranty

The manufacturer guarantees the thermal desorber meets the requirements of technical specifications if the buyer observes proper transportation, storage, installation and operational conditions.

The warranty period is 12 months from entry into service (EIS), but not more than 18 months since acceptance.

8 Claims

In case of thermal desorber failure within warranty period it is necessary to:

- draw up a technically reasoned act of defects concerning its incompliance with technical requirements, specified in section 1.2;
- make abstracts from section "Acceptance certificate";
- specify performed maintenance procedures.

The claim should be sent to the address:

Special Design Office "Chromatec", 94 Stroiteley Str., Yoshkar-Ola, Russian Federation 424000.

Or at Correspondence address: Central post office, P.O. box 84, Yoshkar-Ola, Mari-El republic, Russian Federation, ZIP code 424000.

In Russian: 424000 г. Йошкар-Ола, ул. Строителей 94, СКБ “Хроматэк”

Or 424000, г. Йошкар-Ола, Главпочтамп, а/я 84.

tel/fax: +7(8362) 68-59-16

E-mail: mail@chromatec.ru

Other phones of manufacturers departments:

R&D department	+7(8362) 68-59-35
Marketing department	+7(8362) 68-59-18
Service department	+7(8362) 68-59-19, 68-59-32
Sales department	+7(8362) 68-59-69, 68-59-70