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VT Control

Variable temperature control unit and probe

NO MEDICAL DEVICE

1. TABLE OF CONTENT

2. SAFETY

2.1. SAFETY INSTRUCTIONS

- Please read the following instructions carefully before operating the machine and refer to them as needed to ensure the continued safe operation of your machine.
- The appliance may only be installed and operated in dry, well-ventilated and dust-free rooms.
- Always check voltages and polarization of the adapter before connecting it.
- The unit must be securely placed in a vibration free environment. Adhere to the instructions on ambient conditions when setting up the device and before operation. Operational elements on the front of the machine (mains switch) must be easily accessible. The louvers at the bottom and front of the devices must be free at all times to allow sufficient heat transfer from inside the device.
- Users should not connect any devices other than those specified. This may cause damage to the device or other components.
- Care should be taken so that objects do not fall, and liquids are not spilled into the enclosure through any openings.
- Do not operate the device if the power cord, the power supply unit or the test unit are damaged!
- In case of damage, the appliance must only be opened by an authorized service technician. In this case, return the device for repair.

Caution: The airstream coming out of the VT control unit can be cold or hot.

Caution: Handle cold or hot samples carefully.

Caution: Do not block the air outlet "Air Out" of the VT system.

Caution: Do not put flammable materials on or in the VT system or sample tube.

Caution: Do not put materials in or on the VT system or sample tube that can emit dangerous/toxic fumes when exposed to temperatures that can be reached with the VT probe.

Caution: Never let the VT system run unattended or leave the room while it is running.

This device is intended for **educational** or **research** usage only.
Using it for medical, diagnostic, or biological experiments on living or dead animals or tissue is prohibited.

Notes on care:

- Remove any contamination with a suitable solvent.
- Do not use aggressive cleaning agents such as thinner or acetone for cleaning the surface.

Transportation notes:

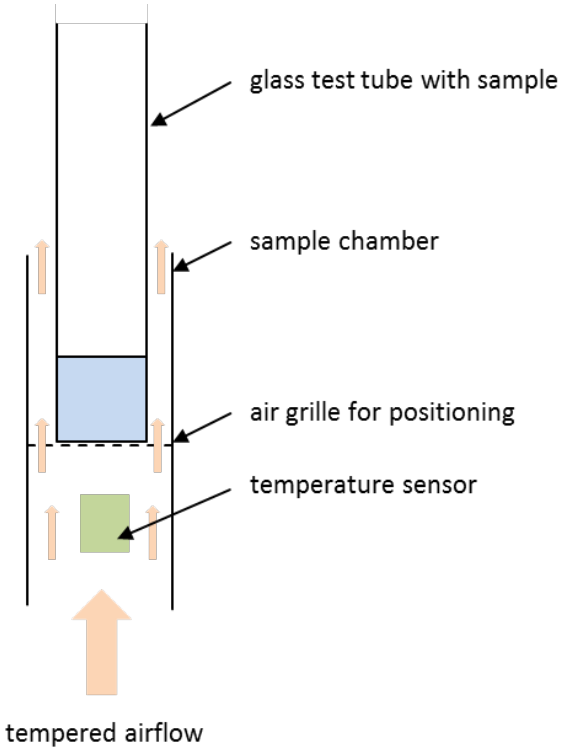
- Transportation of the device is only recommended in the transport case provided by the manufacturer.
- Avoid high shock loads and vibrations during transport. This may damage the control unit and the magnet.
- Do carry the magnet only on the handles provided.

2.2. OPERATING INSTRUCTIONS

- This high-quality instrument fulfills all of the technical requirements that are compiled in current CE guidelines. The characteristics of this product qualify it for the CE mark.
- This instrument is only to be put into operation under specialist supervision in a controlled electromagnetic environment in research, educational and training facilities (schools, universities, institutes and laboratories).
- Use only the provided cables for cabling/wiring. To ensure compliance, use only the provided manufacturer's approved power cord. The user is cautioned that changes or modifications to the equipment not expressly approved by the party responsible for compliance could void the user’s authority to operate the equipment.
- Electrostatic discharges may affect the function and reliability of the device.
- The unit contains electronic components that are very sensitive to electrostatic discharge (ESD). To avoid ESD, do not use the device on carpeted floors.
- This device is registered for business and industrial use and can be used in areas other than general household.
- The use on living or dead human or animal samples or tissues is not allowed.
- The product is no medical product.

3. INTRODUCTION

The sketch below provides a simplified representation of the airflow through the variable temperature (VT) probe. The tempered air coming from the VT control unit passes a thermocouple type T temperature sensor on its way along the glass test tube containing the sample. This temperature is used as input signal for a temperature control loop.



Dried air is required for applications where the air needs to be cooled. To prevent the heat exchanger from freezing over with water ice, the dew point of the dried air should be below -20 °C.

Important: Please note that the measured temperature value is the air temperature below the sample. This is also the temperature that is controlled. To get the corresponding actual sample temperature an additional measurement of the temperature inside the sample may be required.

4. COMPONENTS AND ASSEMBLY

4.1. VT CONTROL UNIT

The Variable Temperature (VT) control unit serves as the primary instrument for regulating the sample temperature. Its versatility allows for both cooling and heating of the airflow, thereby facilitating the tempering of the sample.

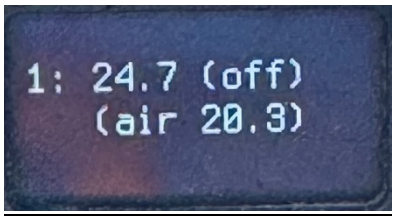
4.1.1. FRONT PANEL

The front panel has the following elements:

Switch: **Power**
The power switch turns the VT control on or off.

Display: **Info**
The display provides information about the current state of the controller (on or off) and the temperature of the temperature sensors that are attached to port 1 and 2.

If no temperature sensor is connected to port 2, then a number indicating the air pressure is displayed instead.



Interface: **Air Out**
This 6 mm outlet provides the tempered air and should be connected to the probe. Please use a short hose (≤ 60 cm) for best performance. Additional thermal insulation is recommended when working with cold air.

Temperature sensor: **1**
Port for thermocouple type T temperature sensor that is used as feedback for the temperature control loop.

Temperature sensor: **2**
Port for additional thermocouple type T temperature sensor that can be used for calibrating the sample temperature.

Interface: **Ext.**
No function.

4.1.2. REAR PANEL

The rear panel offers the connector for the external power supply and the USB-B port, which is essential for establishing the connection to the PC that executes the control software.

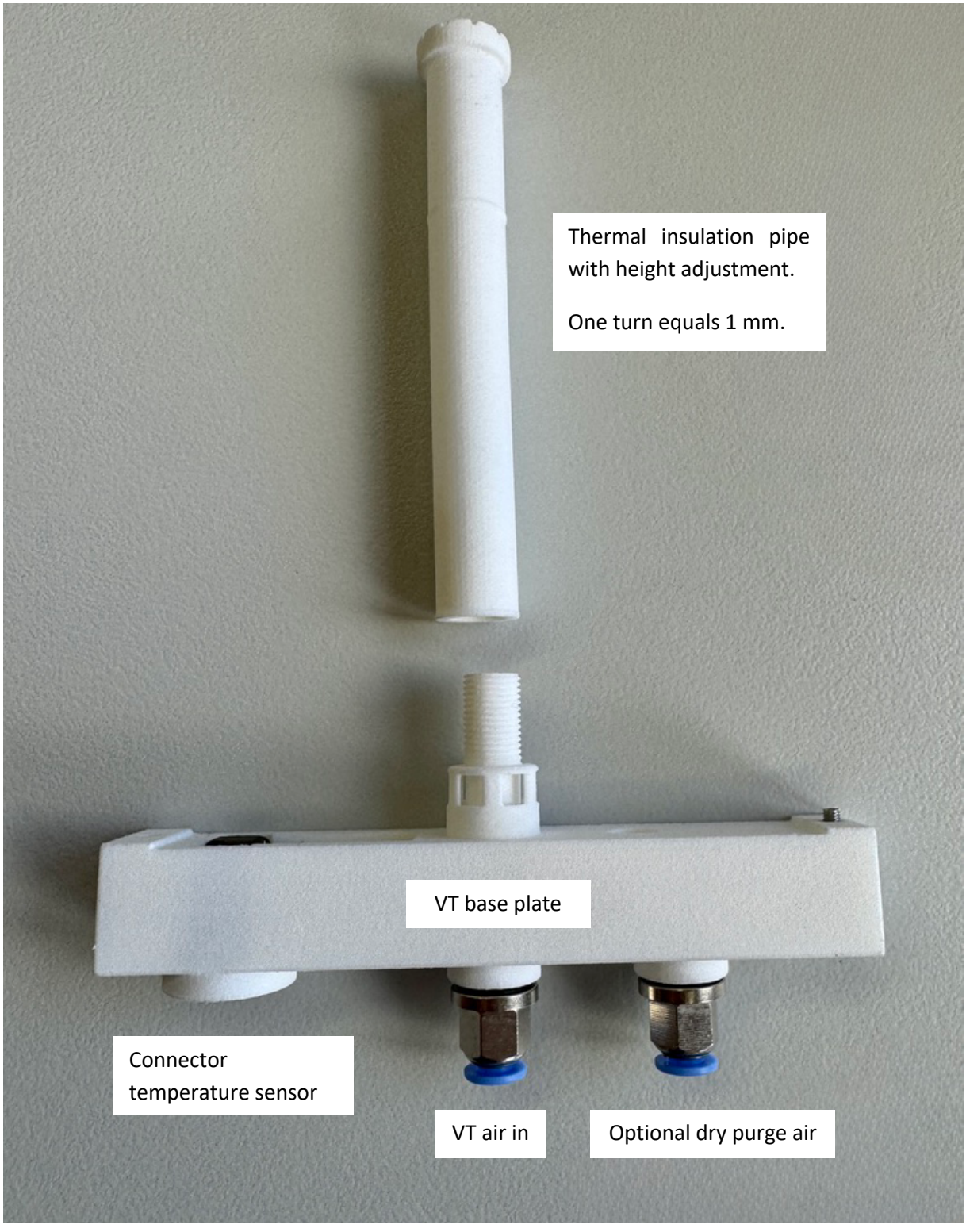
Interface: **Dry Air In**

8 mm inlet for dried compressed air. Dried air with a dew point of less than -20 °C is required when cooling the sample. An adjustable air flow between 5 to 25 l/min is recommended.

4.2. PROBE EXTENSION

4.2.1. DESCRIPTION OF THE PROBE EXTENSION FOR THE 15 MM PROBE

The photograph below shows the components required for connecting the VT control unit to the 15 mm probe.



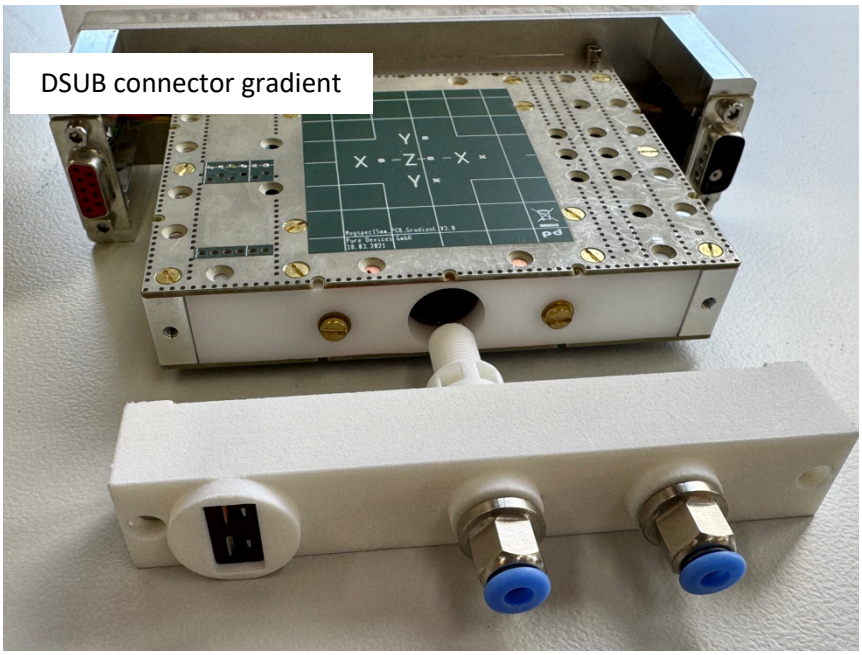
The VT base plate is equipped with a connector for the integrated thermocouple temperature sensor and two inlets for air connection.

The “VT air in” port must be connected to the "Air Out" port of the VT control unit. Additional thermal insulation is recommended for this connection, particularly when operating with low temperatures.

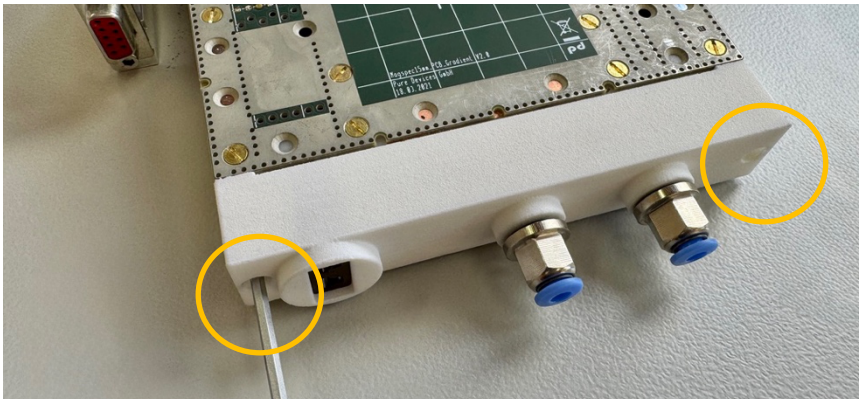
The second air inlet is intended for optional dry air, that will purge the probe and minimize condensation of water when working with activated cooling. Compressed air at a pressure of 2 to 20 mbar (0.03 to 0.3 psi) is recommended for optimized performance.

4.2.2. ATTACHING THE PROBE EXTENSION TO THE 15 MM PROBE

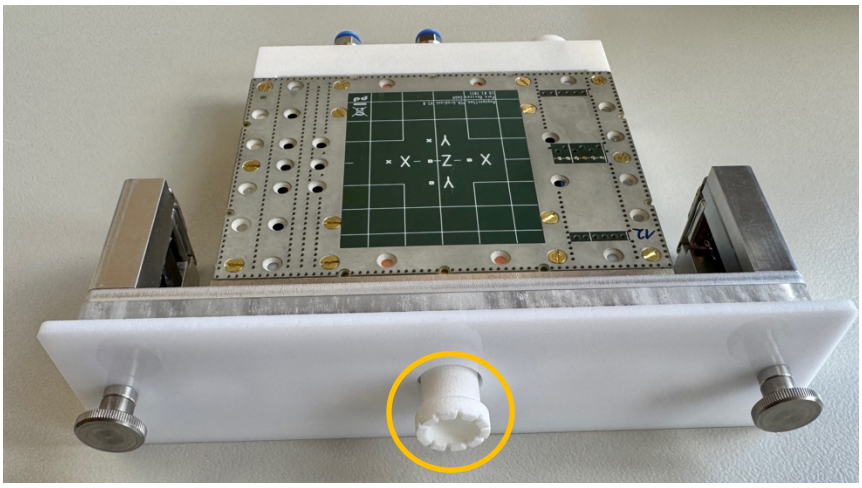
At first, position the VT base plate below the 15 mm probe. It is important that the connector for the temperature sensor is on the same side as the DSUB connector for the gradients.



Then, use the two M3 hexagon socket screws (M3 x 12) to mount the base plate to the probe.



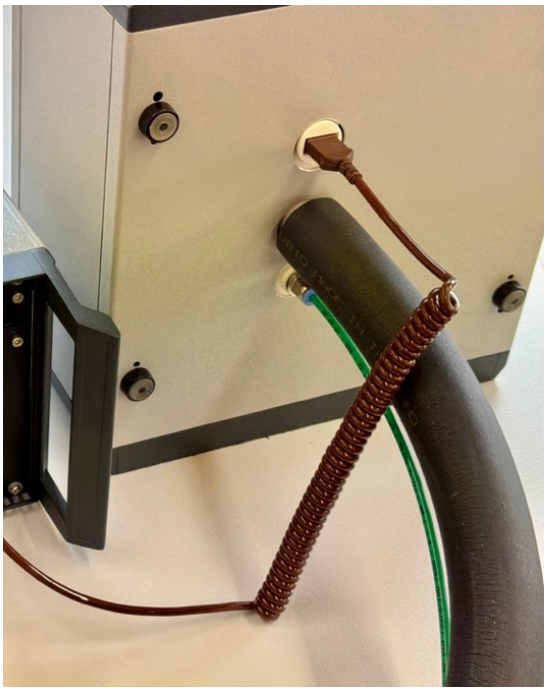
When this is done, screw in the insulation pipe from the top of the probe.



Finally, position the probe in the magnet.

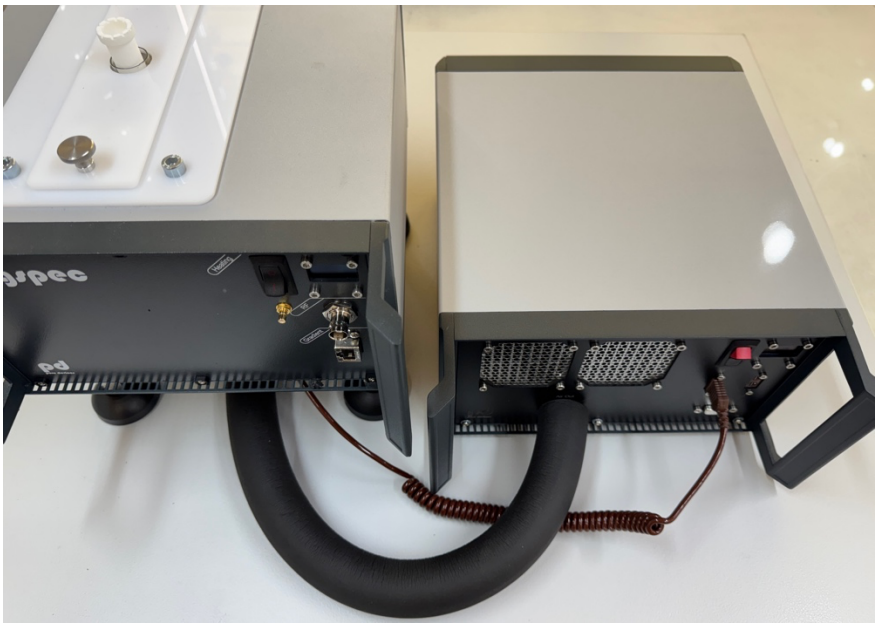
4.3. EXEMPLARY SETUP

The bottom side of the magnet with the VT control unit connected to the probe may look like shown in the photograph below.



Please be advised that the 6 mm tube connecting the "Air Out" port of the VT control should not exceed a length of 60 cm. If this connection is kept short, heat losses are reduced, and a lower temperature can be achieved. It is also strongly recommended that this connection is thermally insulated, in particular when working at low temperatures.

In normal operation mode, the photograph below may be representative. Please note that an additional stand is required beneath the magnet.



4.4. ESTABLISHING THE CONNECTIONS

Connect the PC to the USB-B port at the rear side of the magnet using a USB-A to USB-B cable.

4.5. SAMPLE

The sample should be filled in a glass test tube with an outer diameter of max. 10 mm. It is important to not use samples that might inflame or generate dangerous and/or toxic fumes when exposed to temperatures that can be reached with the VT control unit setup.

A low fill-level of the sample may reduce a possible temperature gradient along the glass test tube. Therefore, it is recommended to have a fill-level between 5 mm to 20 mm for the first measurements. Please note that future experimental results might suggest a different recommended fill-level.

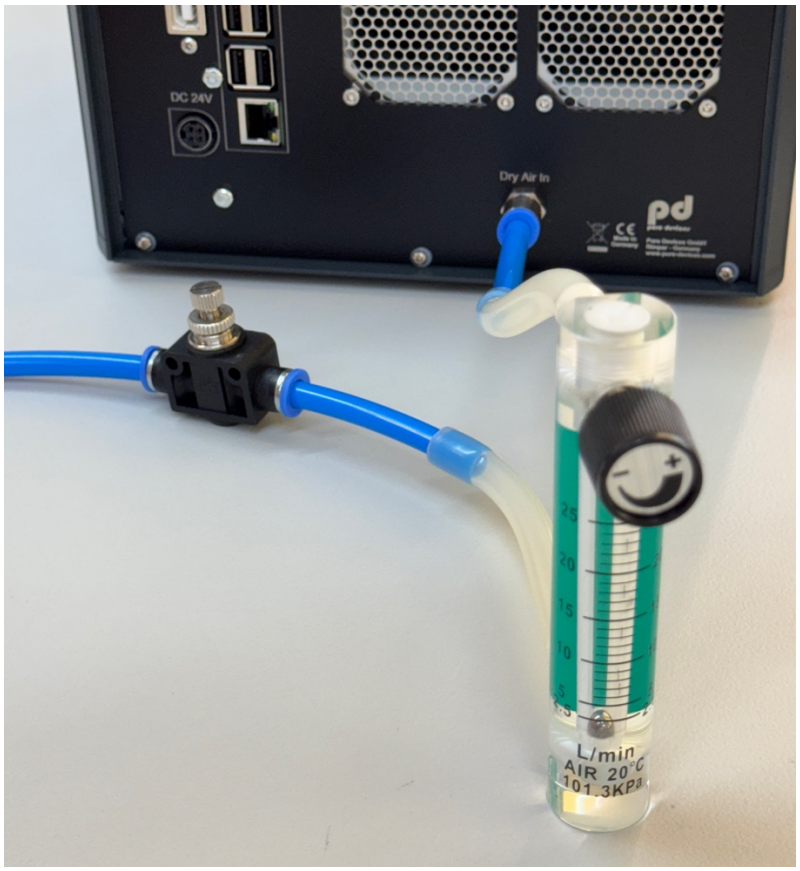
It is important to note that – depending on the sample characteristics – it may take shorter or longer until the equilibrium temperature has been reached.

4.6. ADJUSTING THE AIR FLOW

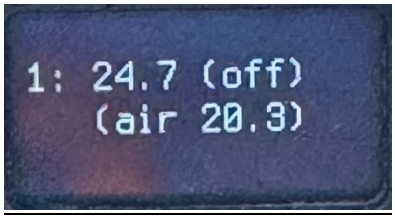
The air flow through the VT control unit should be in between 5 to 25 l/min. A value of 15 l/min is recommended.

The air pressure can be easily adjusted with an air flow meter and a valve that is inserted into the 8 mm hose before connecting to the “Dry Air In” connection.

The photograph below shows a basic setup with valve and air flow meter.



When the VT control unit is turned on and no temperature sensor is connected to port 2, then a value related to the air pressure at a certain flow rate is shown on the display. This value can be used to check whether the air pressure and therefore the flow rate is changing.



Please note that this value can change due to thermal expansion. Furthermore, this value depends on the hose length connecting the "Air Out" port with the probe and on the sample diameter.

5. HOW TO USE

Once everything is set up, make sure the VT control unit is turned on and connected to the PC.

(1) Please adapt the associated `LoadMySystem.m` file so that it contains the following line:

```
% LoadMySystem.m - file
HW.SampleHeater.use = true;
```

(2) Controlling the VT probe in Matlab can be done by accessing the property `HW.SampleHeater.targetTemperature`. Setting a temperature value (in degrees Celsius) within the valid range starts the control process once a minimum air pressure is detected.
Turning off the control process can be done by assigning a NaN value to that parameter:

```
HW.SampleHeater.targetTemperature = NaN;
```

A method named

```
HW.SampleHeater.waitForTemperature()
```

blocks execution until the temperature has settled. Calling this method with the input argument `true` (i.e., `HW.SampleHeater.waitForTemperature(true)`) will output some status information in the command window while heating up or cooling down.

Alternatively, one can periodically check `HW.SampleHeater.checkTemperature()`. This function returns `false` while the temperature has not yet settled. It returns `true` when it has settled.

The following example sets the temperature to 30 °C, waits until the temperature has settled and turns the airflow off again.

```
LoadSystem;
HW.SampleHeater.targetTemperature = 30;
HW.SampleHeater.waitForTemperature(true);
HW.SampleHeater.targetTemperature = NaN;
```

Given the easy-to-use interface, existing sequences can be easily amended with commands for temperature control of the sample.

The following provides an overview of the accessible properties and methods:

- `HW.SampleHeater.targetTemperature`

  Gets or sets the target temperature in °C.

- `HW.SampleHeater.isOnAirflow`

  Checks if airflow is on or off.

- `HW.SampleHeater.enableCooling`

  Enables or disables (default) active cooling of the air.

- `HW.SampleHeater.checkTemperature()`

  Checks if the target temperature has been reached. Returns 1 if true, else 0.

- `HW.SampleHeater.waitForTemperature(verbose)`

  Will wait until the target temperature has been reached. If the optional input parameter `verbose` is set to `true`, verbose output about the current state is enabled.

  Following properties affect the behavior of this method:

  - `HW.SampleHeater.targetTemperatureWaitTime`

    Once the target temperature has stabilized, it will wait the duration defined by this property (default 12 s).

  - `HW.SampleHeater.targetTemperatureDevMax`

    Maximum allowed deviation to the target temperature in °C (default 0.1).

  - `HW.SampleHeater.targetTemperatureStdevMax`

    Maximum allowed standard deviation of the temperature control in °C (default 0.125).

- `HW.SampleHeater.getTemperaturePort1()`

  Gets the current air temperature (port 1). Returns NaN if no temperature sensor is connected.

- `HW.SampleHeater.getTemperaturePort2()`

  Gets the temperature of the temperature sensor connected to port 2. Returns NaN if no temperature sensor is connected.

- `HW.SampleHeater.getAirPressureValue()`

  Returns the current value which is an indication for the air pressure.

- `HW.SampleHeater.targetTemperatureMin`,
  `HW.SampleHeater.targetTemperatureMax`

  Gets the minimum or maximum target temperature that can be set by the user in °C.

Additional documentation is available in Matlab with the command

```
doc PD.SampleHeaterBase;
```

6. APPENDIX

6.1. TECHNICAL SPECIFICATIONS

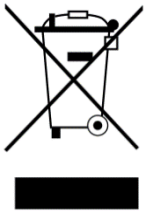
VT control	
Room temperature	≤ 22 °C
Minimum continuous target temperature	4 °C
Maximum continuous target temperature	50 °C
Maximum power	< 120 W
Standby power	< 5 W
Recommended airflow	15 l/min (5 to 25 l/min, adjustable via air flow meter)
Maximum airflow	approx. 30 l/min (without obstructing sample)
Max input pressure	300 mbar (4.4 psi)
Recommended dew point of air for cooling	≤ -20 °C
Recommended input pressure (purge air)	2 to 20 mbar (0.03 to 0.3 psi)
Dimensions L × W × H	27 cm × 25 cm × 14 cm
Weight	5 kg

6.2. GUARANTEE

We guarantee the instrument supplied by us for a period of 24 months within the EU, or for 12 months outside of the EU. This guarantee does not cover natural wear nor damage resulting from improper handling.

The manufacturer is responsible for the safety and function of the instrument. Maintenance, repairs or modifications should only be performed by authorized personnel.

6.3. WASTE DISPOSAL



The packaging consists predominately of environmentally compatible materials that can be passed on for disposal by the local recycling service.

This product does not belong into the household waste. For professional disposal send the device directly to the address below.

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7. PRODUCT INFORMATION

For further information about the product or the manufacturer, please visit our website

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