FERROVAC GMBH

ULTRA HIGH VACUUM TECHNOLOGY

Liquid nitrogen UHV Booster and Fast Pump Down Dock

CTH40/CTDH40/VSCT40

INSTRUCTION MANUAL

Version 3.0

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Terms and symbols

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A triangle with explanation mark indicates a passage in the manual with information that is crucial for the operator. READ THESE PARAGRAPHS CAREFULLY or the product might be damaged by misuse.

A triangle with a snow flake indicates a passage in the manual with information that is crucial for the operator with respect to cryo cooling and handling cryogenic liquids. READ THESE PARAGRAPHS CAREFULLY in order to protect the operator from any injury.

A triangle with a gas bottle indicates a passage in the manual with information that is crucial for the operator with respect to laboratory gases under pressure. READ THESE PARAGRAPHS CAREFULLY in order to protect the operator from any injury.

WARNING! The WARNING heading in a manual explains dangers that may result in personal injury or death. Always read the associated information very carefully.

CAUTION! The CAUTION heading in a manual explains hazardous situations that could damage the product. Such damage may invalidate warranty.

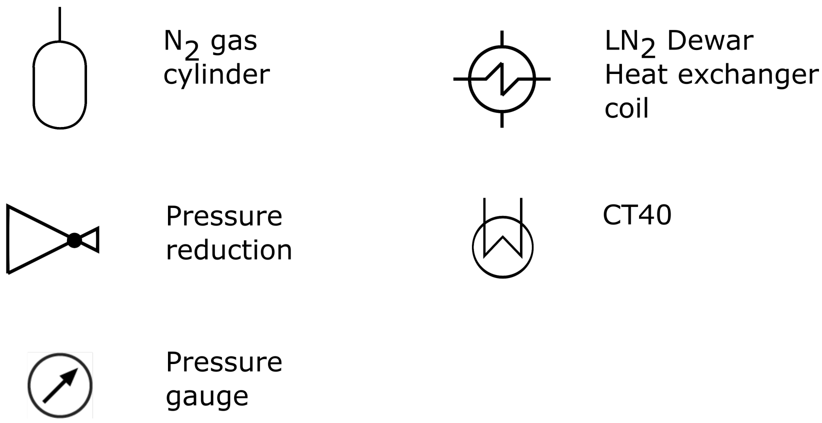


Figure 1: Symbols used in the drawings.

Normal use

The product described in this manual must always be used:

- In an indoor research laboratory environment
- By personnel qualified for operation of delicate scientific equipment
- By personnel trained in using cryogenic liquids and gas handling systems
- In accordance with all related manuals.

CAREFULLY READ THE SAFETY INFORMATION AND ALL RELEVANT MANUALS BEFORE USING THE PRODUCT AND ANY RELATED INSTRUMENTATION!

WARNING: Cryogenic liquids, liquid nitrogen (LN_2)

The handling of liquid nitrogen is only allowed by authorized and trained personal respecting the general safety precautions for cryogenic liquids.
In addition to this manual, read carefully the safety instructions given by your liquid nitrogen supplier.

WARNING: Gaseous nitrogen (N_2) in high-pressure cylinders

The handling of industrial nitrogen gas in high-pressure cylinders is only allowed by authorized and trained personal respecting the general safety precautions for compressed gases.
Do not drag, slide or roll cylinders. Use a suitable hand truck for cylinder movement. Use a pressure reducing regulator when connecting the cylinder to lower pressure piping or systems. Secure the cylinders against tripping.
In addition to this manual, **carefully read the safety instructions given by your supplier for nitrogen gas**.

WARNING: Liquid nitrogen (LN_2), nitrogen gas (N_2)
Nitrogen is a colourless, odourless and tasteless non-toxic substance. LN_2 is a clear liquid. Be aware that an amount of 1 liter liquid turns into about 700 liters of gas which can cause large pressure build up in a closed system when warming up. Make sure to take precautions for overpressure and prevent any blocking by ice formation.
LN_2/N_2 can cause rapid **suffocation** without noticing, therefore these substances have to be stored and handled in areas with **adequate ventilation**. Be aware that N_2 gas starts to accumulate on the ground.

If any symptoms such as drowsiness, dizziness, headache, unconsciousness or even vomiting occur, bring victim to fresh air, provide oxygen or artificial respiration if needed. Look for professional medical assistance.
LN_2 can cause severe frostbite. In case of injury, warm up exposed parts, but don't use hot water. Look for medical assistance.

The handling of liquid nitrogen is only allowed by **authorized and trained personal** respecting the general safety precautions for cryogenic liquids.
Always use the personal protective equipment (PPE), i.e. wear safety glasses and gloves as well as closed stable shoes and long sleeves/pants.
In addition to this manual, read carefully the safety instructions given by your supplier of liquid nitrogen and the storage vessels.

Safety precautions

The following safety precautions must be observed at all times before using the product described in this manual and any associated instrumentation.
The product described in this manual is intended for use by qualified personnel who recognize shock hazards and are familiar with the precautions necessary to avoid possible injury.

Responsible body is the individual or group of persons that are responsible for the proper use and maintenance of the product, ensuring that the product is operated within its specifications and operating limits. The responsible body must ensure that users of the product are adequately trained.

Operators are using the product for its intended purpose. Operators must be trained in basic laboratory safety, basic electrical safety, handling of cryogenic liquids and adequate use of scientific instruments, in particular ultra high vacuum systems. They must be protected from electric shock, frost bite and contact with potentially dangerous situations.

Maintenance Personnel perform routine tasks on the product to keep it in proper operating conditions i.e. controlling the LN_2 filling lines, cooling setups, gas bottles, dewars or replacing consumables. Maintenance procedures are described in the manual and must be followed at all times.

Service Personnel are trained to work on ultra high vacuum equipment, gas handling systems, pressurized gas cylinders and cryogenic liquids as well as perform fault finding measurements and repair work to the product. Only fully trained service personnel is settinng up the gas filling lines, gas bottles, etc. which are necessary for a proper operation of the product.

CAUTION: Cryogenic liquids are only allowed to be used in laboratories with proper ventilation.

WARNING:

- **Always** observe and strictly follow the safety notes and regulations given in this and related documentations.
- **Always** use the configured cables delivered with the product for electrical connections.
- **Always** disconnect the mains supplies of all electrically connected units before venting, pump-down, opening the vacuum chamber, touching any part of the in-vacuum components.
- **Always** observe and strictly follow the safety notes and regulations given in this and related documentations.
- **Read** safety instructions first and be familiar with general safety precautions for cryogenic liquids and compressed gases.
- **Always** strictly follow the safety notes and regulations of handling cryogenic liquids given by the vendor of cryogenic liquids.
- Make sure that a **proper ventilation** is present in the laboratory while using cryogenic liquids.

Ambient conditions and environments:
This product is only to be used indoors, in laboratories meeting the following requirements:

- Room temperature lies between 5°C/41°F and 40°C/104°F.
- Relative humidity up to maximum of 80% for temperatures up to 31°C decreasing linearly to 5% relative humidity at 40°C.
- Altitudes up to 2000 m.
- Pollution Degree 2 environments.
- Mains supply voltage fluctuations must not exceed $\pm 10\%$ of the nominal voltage.
- The device should only be operated at the **indicated mains supply voltage**.

The resonsible body needs to make sure that the typical safety standards in a laboratory are fulfilled and every collaborator in the laboratory has access to personal protection equipment (PPE) according to the safety standards and receives an appropriate safety training.
Besides wearing long sleeves and solid closed shoes for handling cryogenic liquids the PPE consists at least of

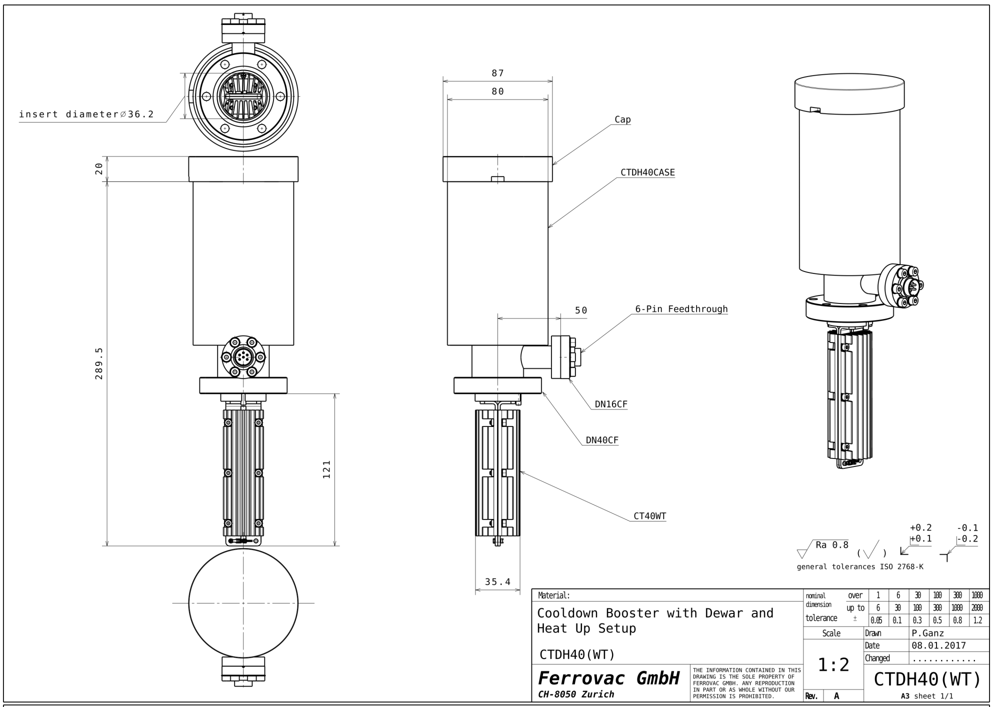
- Personal eye/face protection (see also EN 166)
- Protective gloves against cold (see also EN 511)
- Possibly personal protective shoes (EN ISO 20345)

The general safety measures for gas handling systems need to be considered. In addition the following standards might be considered as well:

- ISO/NP 23555-2 Gas pressure safety and control devices for use in gas transmission, distribution and installations for inlet pressures up to and including 10 MPa – Part 2: Pressure regulators
- ISO 11625:2007 Gas cylinders – Safe handling

Technical Specifications

CTH40:	
Flange type	DN40CF
Heat exchanger	Aluminum cooling blocks
Core	OFHC (Copper), stainless steel
Heating wire	Tungsten filament $\varnothing\, 0.25$ mm
Max. heating current	4.0 A
Cryogenic liquids	Liquid nitrogen only
Maximum allowed inlet pressure	2.5 bar
Temperature sensor type	Pt100
Temperature range sensor	-200°C – 170°C
Maximum heating/baking temperature	+150°C
Miniature feedthrough:	
Pins	$6 \times \varnothing$ 1.6 mm
Test voltage	500 V DC
Max. voltage for device usage	49 V
Max. current	5 A
CTDH40:	
Flange type	DN40CF
Heat exchanger	Aluminum cooling blocks
Core	OFHC (Copper)
Heating wire	Tungsten filament $\varnothing\, 0.25$ mm
Max. heating current	4.0 A
Cryogenic liquids	Liquid nitrogen only
Filling volume	~ 0.7 l
Temperature sensor type	Pt100
Temperature range sensor	-200°C – 170°C
Maximum heating/baking temperature	+150°C
Miniature feedthrough:	
Pins	$6 \times \varnothing$ 1.6 mm
Test voltage	500 V DC
Max. voltage for device usage	49 V
Max. current	5 A
Flange type	DN16CF
VSCT40:	
Maximum bakeout temperature	150°C
Leak rate	$< 5 \times 10^{-10}$ mbar
Maximum overpressure	0.3 bar (windows)
Tolerances for chamber:	
Machine parts	ISO 2768 -m -K
Welded parts	± 1 mm and $\pm 1°$



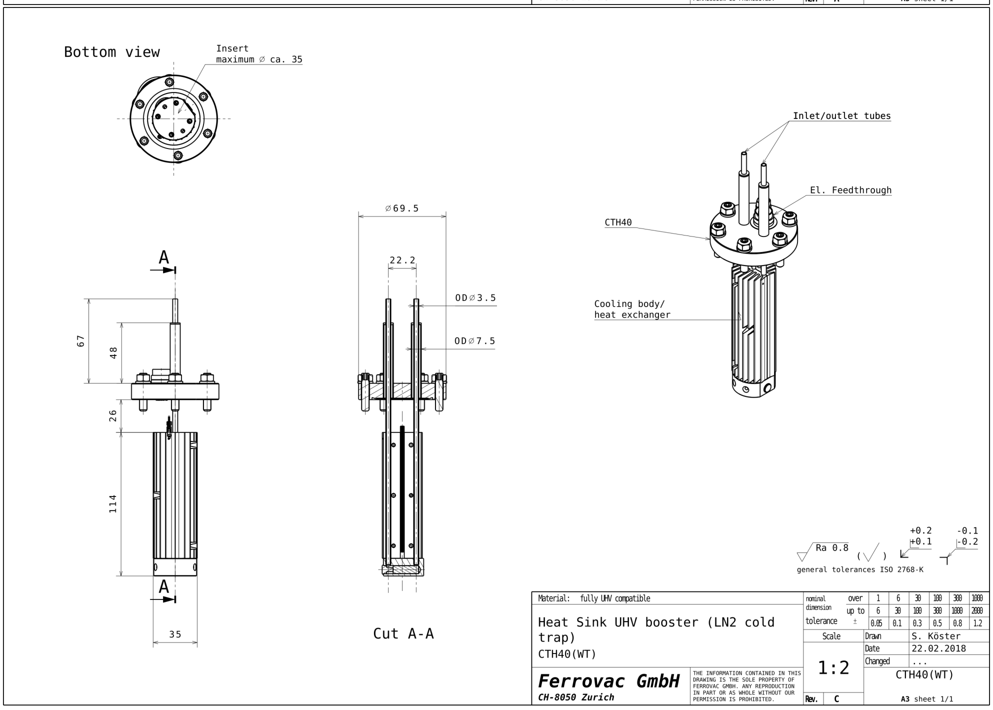


Figure 2: Overview drawings of the **CTH40** (top) and **CTDH40** (bottom) with their components. The original drawings can be downloaded from our homepage in the category UHV suitcase accessories.

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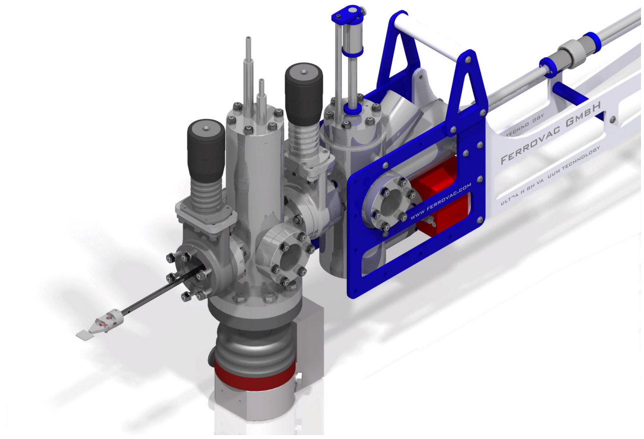


Figure 3: Example image for usage of the **VSCT40 with cold trap and our NexGeneration UHV suitcase.**

1 Introduction

The **CTH40** and **CTDH40** are UHV boosters intended to be used with a small transfer chamber (for example as our fast pump down dock VSCT40, Fig. 3). They enable an exceptionally fast transfer of samples from a portable UHV-suitcase (e.g. VSN40S) into the UHV-System. Vacuum in the transfer chamber is created using a turbo pumping system while the UHV boosters act as additional **cryogenic pump**. Thus a sufficient vacuum is established within approximately 30 minutes, as opposed to many hours when pumping the buffer volume conventionally. On top the water partial pressure will be reduced. For a fast warm-up, the **CTH40** and **CTDH40** can be heated vie a tungsten filament while the temperature can be monitored via a Pt100 temperature sensor.
The **CTH40** and **CTDH40** can be ordered as stand-alone products or together with a chamber and valve, the **VSCT40**. The turbo pumping system and cool-down equipment are not part of the product. Configured cables can be ordered separately or as a kit with a small power supply.

2 Unpacking and inspection

Before unpacking, inspect the parcel for any visible damage. If any evidence for damage of the package is found, take pictures of the parcel and send them to FERROVAC GMBH immediately.
Compare the contents of the package with the delivery note. Any damage or missing items must be reported to FERROVAC within 48 hours after delivery.
Prepare a very clean workspace. Carefully unpack the **CTH40** and perform a visual check for any damage of the package, its contents and accessories. Only touch the vacuum side parts of the **CTH40** with clean, powder-free gloves.
The **CTH40** and **CTDH40** are shipped fully assembled as one piece and cleaned, see Fig. 4.
Compare the contents of the package with the delivery note. Any damage or missing items

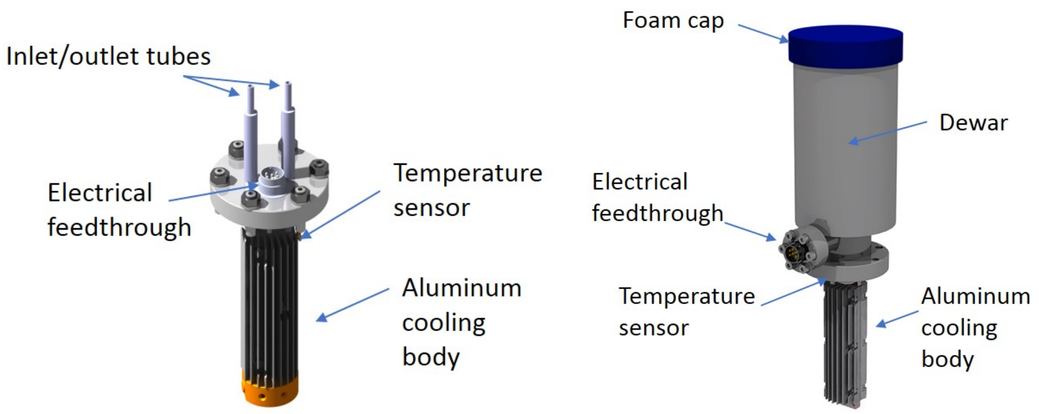


Figure 4: Overview of the **CTH40** (left) and **CTDH40** (right) with their components.

must be reported to FERROVAC GMBH within 48 hours after delivery.

The package should contain for CTH40:

- The fully assembled CTH40
- This manual
- Optional: Cabling
- Optional: Subsequent manuals (if applicable e.g. for a kit)

The package should contain for CTDH40:

- The fully assembled CTDH40
- A blue foam cap
- This manual
- Optional: Cabling
- Optional: Subsequent manuals (if applicable e.g. for a kit)

For VSCT40:

- Fully assembled VSCT40 with gate valve (optional without gate valve)
- This manual
- Optional: cabling
- Subsequent manuals (e.g. gate valve)

CAUTION!

- **Please ensure enough working space on a clean table for unpacking and inspection, use powder-free examination gloves.**
- **Read this manual carefully before using the device.**
- **Never expose the body of the CTH40 to physical shocks or aggressive chemicals.**
- **Never hit the knife edge.**

3 Overview and description

The **CTH40** and **CTDH40** are cooled down with liquid nitrogen (LN_2) in order to cool the cryo pump body attached on the vacuum side.
In case of the **CTH40** liquid nitrogen flows through the tube in which a porous material is placed in order to enhance the surface for cooling and slow down the flow within the tube. The **CTH40** can be connected to a liquid nitrogen supply via the tube fittings on top of it. It does not matter which tube is used as inlet or outlet. The liquid can be blown out by purging with dry nitrogen gas. The **CTDH40** has a dewar which is filled with liquid nitrogen to cool down a heat exchanger which is directly attached to it on the vacuum side. Both devices have a tungsten filament built-in which can be used for fast warm-up of the device. The temperature can be monitored by a Pt100 sensor attached inside.
For the details of the procedures and handling read the respective chapters of this manual.

4 Setup and installation

Carefully unwrap the device and make sure not to hit the knife edges. All parts are shipped in a clean state, therefore use gloves for unpacking.

4.1 Installation on a UHV chamber

Install the **CTH40**/**CTDH40** in a suitable chamber with sufficient space on a DN40CF flange with a Cu gasket. The available inner diameter should be at least 38 mm. (Some DN40CF flange tubes might be too small!) For optimized pumping speed it is advisable to use an oversized tube flange with e.g. about 64 mm inner diameter or the open space of a chamber.
The **CTH40** can be installed with the tube openings in a vertical/up-right, horizontal or orientation in-between. The **CTD40** can only be installed in an up-right position!
If the product was delivered together with a buffer chamber, the VSCT40, attach the chamber to your system via the CF40 flange with the valve (or free CF40 flange if no valve is attached). The bottom CF63 flange is meant for attachment of a turbo molecular pump (turbo pump). It

Figure 5: Demonstration of mounting orientations for the **CTDH40** and **CTH40**. The **CTDH40** should only mounted in the up-right orientation.

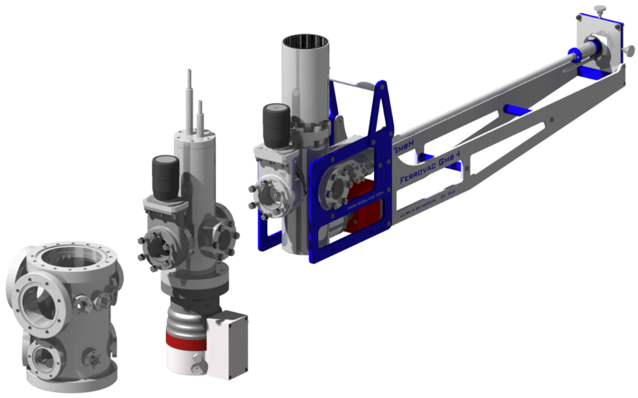


Figure 6: Schematic example for the usage of the **VSCT40** with a chamber together with our NexGeneration UHV suitase. (Be aware that the valve and short flanges of the **VSCT40** have tapped holes.)

could be necessary to add a mechanical support for the VSCT40 and its turbo pump installed. This has to be provided by the customer and adapted to the respective system.

> **CAUTION:**
> **CF knife edges are very sensitive!** Avoid using any sharp instrument in the vicinity of the knife edge. CF flanges must be handled by qualified personnel only!

4.2 Temperature measurement and heating

The **CTH40** and **CTDH40** have a Pt100 temperature sensor installed inside. For the wiring diagram please refer to Fig. 10 (and Fig. 11 if you have bought the respective cable).
Useful items:

- CABCTH40HTB4M, CABCTH40HT4M or your own cabling
- Multimeter
- Standard laboratory power supply for at least 48 W.
- Optional: temperature detection for a Pt100 sensor.

If using CABCTH40HTB4M or CABCTH40HT4M connect the 6-pin connector to the feedthrough in the appropriate orientation.
The temperature measurement can be done as 4-wire or 2-wire measurement. The latter is usually enough, but less accurate. (A little margin should be taken into account for a 2-wire measurement.) For the 2-wire measurement just connect $-V$ and $+V$ to a multimeter. If using CABCTH40HTB4M or CABCTH40HT4M connect one black (-) and one yellow (+) banana plug to a multimeter for resistance measurement. Leave the other two disconnected without producing a short circuit.
If a 4-wire measurement should be performed, a constant current of 1 mA is recommended. Connect $-I$ and $+I$ for the current and $-V$ and $+V$ for the voltage measurement. If using CABCTH40HTB4M or CABCTH40HT4M use one black (-) and one yellow (+) banana plug for the current and the other two for the voltage measurement.
For resistance-temperature conversion refer to Fig. 12 or the respective data for Pt100 sensors from internet.

CAUTION!

- Never let the temperature exceed +150°C.
- Only use the heating coil when the device is under vacuum.
- Never apply a current of more than 4 A.
- Always monitor the temperature when using the heating.

Be aware: A current of 4 A can cause temperatures higher than +150°C when the device is in warm state.
Be aware: Only the bakeable cable can be used for typical UHV bake-out, the other cable should not be used for temperatures higher than 40°C.

When using the heating coil, the device should be under vacuum! Before connecting, make sure that the output of the power supply is switched off. Connect the blue ($-I_F$) and red ($+I_F$) banana plug to a standard laboratory supply. A current of up to 4 A (about 12 V) can be applied to the heating coil.
Further details for cool-down and warm-up will be described in the sections below. For available upgrades and options, see Sec. 11. A 4-wire measurement electronics is not available at the moment (and usually not necessary).

4.3 Installation for cool-down

The responsible body is liable to take care of a proper cooling set-up and the respective safety measures.
The installation of a gas handling and cooling system should only be done by trained service personnel. Please read section 6 and decide for an adequate set-up in your laboratory for installation on the system.
In general a bakeout of the cryo trap is not necessary, the purpose of the cryo trap is to shorten transfer times including pump-down procedures. If the system should be baked (see Sec. 8.1) with the cryo trap installed, please make sure that any heat-sensitive material as plastics etc. can be removed an no overpressure would built up in the tube system.

5 Preparation for vacuum usage, venting

This section describes the procedures for a potential initial bakeout and general vacuum usage. During normal operation no regular bakeout is needed. The cryo pump replaces this action to make the pumpdown faster and more efficient.

5.1 Pumpdown

Close the valve and unused flanges or additional valves, depending on what is connected in your setup. Start the roughing pump and subsequently the turbo pumping. If used in warm condition, wait at least 90 min or longer before starting any transfer action of samples.
The cooling can be started shortly after the turbo pumping had been started (not before). Please read section 6.

5.2 Venting

Although the chamber will be opened to air in typical transfer situations, it is recommended to vent the chamber (and turbo pump) first with clean and dry nitrogen gas (N_2). It'll help with faster pump down afterwards, even when opened to air for a short time. The overpressure for the dry nitrogen should not exceed 250 mbar as the windows (**VSCT40**) are not meant to be exposed to large overpressure from inside the chamber compared to normal atmospheric pressure. They could start leaking.

6 Cool down procedures

6.1 Cool-down of the dewar version CTDH40

For cool-down the dewar of the **CTDH40** is filled with liquid nitrogen. (Only operators trained in handling cryogenic liquids are allowed to perform this task.) The dewar should only be filled up to 3 cm below its upper rim! Be careful to not spill large amounts of LN_2 on sensitive parts in the environment (e.g. cabling and windows). When the dewar is filled, place the foam cap on top of the dewar.

6.2 Cool-down of the tube version CTH40

This section contains suggestions for step by step procedures to controlled cool down of the **CTH40**. The responsible body needs to provide a respective set-up including valves, hoses and connectors, liquid nitrogen (LN_2), vessels and nitrogen gas (N_2) cylinders. The set-up should be established by a trained service personnel. The responsible body is liable for the proper and secure set-up of the nitrogen filling system respecting the typical security measures for such systems.

WARNING:
Never close the exhaust line to prevent excessive pressure built-up!

6.2.1 Cool-down with a pressurized liquid nitrogen dewar

It is possible to use a liquid nitrogen vessel that is pressurized to pump liquid nitrogen through the **CTH40**.
Required equipment:

- Liquid nitrogen cylinder with pressurizing possibility, over pressure valve and venting valve
- Liquid nitrogen vessel for exhaust LN_2
- At least 10 liters of liquid nitrogen (the amount of LN_2 used depends on the period of time for which the **CTH40** should be cold).
- Valves, connectors and hoses suitable for low temperature usage
- Hose insulation.

Connect the outlet of the liquid nitrogen cylinder to the inlet tube (long tube) of the **CTH40**. A proper insulation of the hose is recommended (e. g. standard foam insulation for tubes). Do not exert much force onto the tubes of the **CTH40** while fixing the hoses. Connect another insulated hose to the outlet tube (short tube) and let the emerging liquid flow into a proper vessel that is big enough to hold about 5 liters of LN_2. Make sure that the hoses are properly fixed and cannot jump off. Slowly open the valve of the liquid nitrogen cylinder and put the liquid nitrogen cylinder under small overpressure. First flush the system with some nitrogen gas and wait until the system and hoses start to cool down. Then slowly increase the pressure to let liquid nitrogen flow through the system. In general only 0.2-0.3 bar overpressure are sufficient to achieve a liquid nitrogen flow, depending on the cylinder and hoses used. The exhaust liquid should be safely collected in a vessel. Keep a steady flow of liquid nitrogen through the **CTH40**, such that there is always LN_2 in the tube of the **CTH40**. This generally doesn't require a large flow or high pressure.

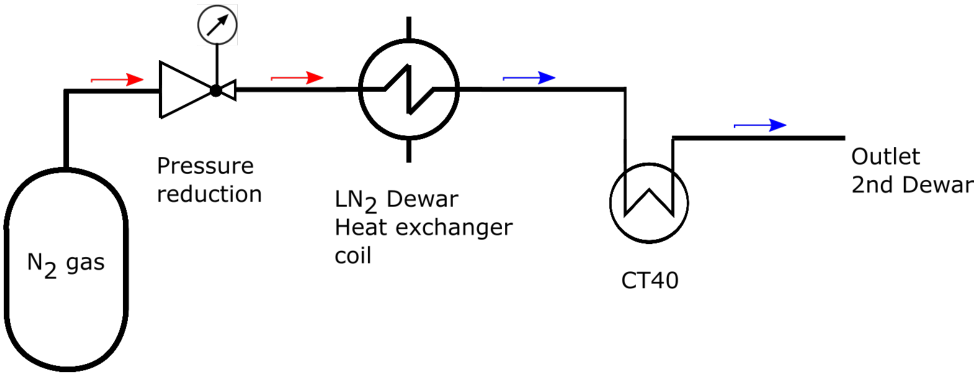


Figure 7: Flow chart for cooling with N_2 gas and heat exchanger.

After about half an hour the **CTH40** is fully cooled down and reaches its base temperature while the pressure should drop more than an order of magnitude. Now you can open the valves for transferring samples. Although the **CTH40** won't warm up immediately, it is recommend not to stop the LN_2 flow too early during transfer. When the transfer is finished stop the nitrogen flow, but don't open or detach the hoses as the system is still cold to prevent condensation in the tube.

6.2.2 Cool-down with liquefying N_2 gas

A second possibility is to cool-down the **CTH40** by liquefying N_2 gas with a heat exchanger. Equipment required:

- High quality N_2 gas in a gas cylinder with pressure regulation
- Cu tube with about 10 loops as heat exchanger
- Liquid nitrogen vessel big enough to insert the heat exchanger tube
- At least 20 liters of liquid nitrogen (the amount of LN_2 used depends on the period of time during which the **CTH40** should be cold)
- Valves, connectors and hoses suitable for low temperature usage
- Hose insulation

Connect the gas cylinder to the heat exchanger coil and the latter to the inlet tube of the **CTH40** according to Fig. 7. The outlet of the **CTH40** should be connected with another tube which can let the exhaust LN_2 flow into another dewar. Let some warm gas flow through the tubes with a pressure of approximately 0.5 bar. Then slowly insert the heat exchanger coil into the LN_2 dewar and increase the pressure towards 2 bar. After about 10 min liquid nitrogen should run through the **CTH40**.
Keep the N_2 flowing during the transfer, that LN_2 runs through the tube. When finished, the pressure can be reduced to 0.5 bar such that the flow of liquid is stopped. When the hoses are

not frozen any more, the heat exchanger coil can slowly be taken out of the dewar. (Depending on the hose material used, the hoses might be slightly heated for warm up, but make sure that the hoses don't become too hot or a high pressure builds up in the system, to prevent any damage.)

7 Warum up procedures

7.1 Warm up CTH40

When the transfer is finished stop the nitrogen flow, but don't open or detach the hoses as the system is still cold. (Be aware that some hoses might break when moved in the frozen state.) Also don't break the vacuum while the system is cold to prevent water condensation and ice formation on the cryo pump. (The cryo pump won't be damaged by water condensation, but it is preferable not to have any water in the chamber.) Without any further action, it takes several hours until the cryo pump has warmed up. Therefore the heating coil can be used to fasten the warm-up procedure.

7.1.1 Warm-up by heating with the heating coil

Connect the heating coil as described in section 4.2. Make sure that the chamber is under vacuum (which should be the case when it is used for cooling). Slowly increase the current up to 4 A and carefully monitor the temperature. Be careful towards the end of the warming procedure when the sensor reaches room temperature. At high currents the temperature might rise fast, therefore the current should be reduced at the end of the heating procedure.

Please be aware that the lower Cu part of the CTH40 takes usually a little longer than the upper part to warm up. Therefore it is advisable to wait about 5 min when the sensor had reached 20°C or higher. Afterwards the temperature should be high enough to vent the chamber without the danger of condensation. The heating has to be switched off before venting the chamber (or otherwise the heating coil can be damaged).

Some example data can be seen in Fig. 9.

CAUTION!

- Never let the temperature exceed +150°C.
- Only use the heating coil when the device is under vacuum.
- Never apply a current of more than 4 A.
- Always monitor the temperature when using the heating.

Be aware: A current of 4 A can cause temperatures higher than +150°C when the device is in warm state.
Be aware: Only the bakeable cable can be used for typical UHV bake-out, the other cable should not be used for temperatures higher than 40°C.

An example program for warming up could use the following steps:

Steps	1	2	3
Current (Voltage)	4 A (~12 V)	3 A (~7.4 V)	2 A (~3.7 V)
Time	5 min	10 min	10 min

Table 1: Suggestion for a warm-up program for **CTH40**. (Voltage statements are only rough numbers as they vary with temperature and exact length of the coil.)

This program is very similar to the one used for the test data in Fig. 9. Using this program it takes about 25 min to reach room temperature while it ensures that everything warms up uniformly.

7.1.2 Warm-up with hot gas

This is a method used for older devices which don't have a heating coil installed. It costs more time and nitrogen gas and is therefore not recommended for devices with a heating coil.
For faster warm up it is possible to let warm or hot N_2 gas flow through the tube at a pressure of about 0.5 – 1.0 bar. In case the heat exchanger method is used, it is also possible to dip the heat exchanger coil into hot water (60°C – 80°C) while N_2 gas is flowing through the tubes to accelerate the process. Warm up would then take about 1.5 – 2 hours. The period of time depends on the flow and temperature of the N_2 gas.

7.2 Warm up CTDH40

The warming procedure for **CTD40** is very similar to **CTH40**. The best is to not fill the dewar to its maximum, but only with the amount of liquid nitrogen needed to perform the transfer.
It is possible to blow out the remaining liquid nitrogen by letting warm nitrogen gas pass into the dewar. This needs to be done carefully and without high pressure. The liquid nitrogen

should not be spilled in such a way that it could harm anybody. The usage of face and hand protection is mandatory.
Before warming up the **CTDH40**, remove the blue cap from the dewar to prevent any pressure built-up. Be aware that the remaining liquid nitrogen will boil more intensively when the device is heated.
Connect the heating coil as described in section 4.2. Make sure that the chamber is under vacuum (which should be the case when it is used for cooling). Slowly increase the current up to 4 A and carefully monitor the temperature. Be careful towards the end of the warming procedure when the sensor reaches room temperature. At high currents the temperature might rise fast, therefore the current should be reduced at the end of the heating procedure. An example program for warming up could use the following steps:

Steps	1	2	3
Current (Voltage)	4 A (~12 V)	3 A (~7.4 V)	2 A (~3.7 V)
Time	TBD	TBD	TBD

Table 2: Suggestion for a warm-up program for **CTDH40**. (Voltage statements are only rough numbers as they vary with temperature and exact length of the coil.)

8 Maintenance

8.1 Bakeout

Under normal conditions a bakeout is not necessary. Nevertheless, it is possible to bake the **CTH40**, **CTDH40** or **VSCT40** with the system. The **CTH40** and **CTDH40** should be baked under vacuum together with its chamber. This can usually be done together with the main system bakeout after installing the **CTH40** and its chamber or on a separate turbo pumping stand. For the bakeout typical baking equipment such as heating cables and aluminum foil or a tent can be used.

- To prevent marks on the chamber from the heating cable, first wrap a protective layer of Al foil around the chamber, before installing the heating tape and more Al foil.
- Cover the windows with Al foil.
- Wrap the complete chamber (without the turbo pump) in Al foli.
- Make sure that all heat-sensitive parts as plastic tubes, covers, etc. are taken out of the bakeout zone.
- The chamber needs to be pumped at least for 15 min.
- Then bake the **CTH40** together with its chamber under high vacuum conditions (pumped with a turbo pumping system) for at least 24 hours at temperatures of 120°C - 150°C. Don't exceed 150°C.

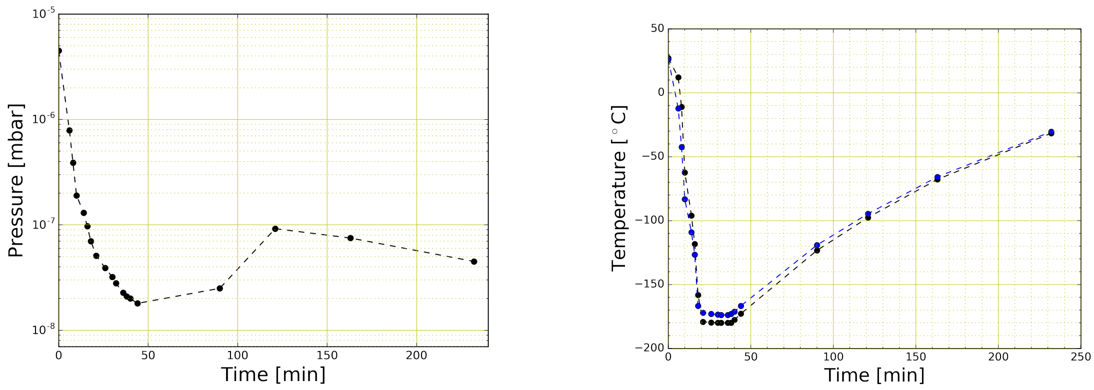


Figure 8: Examples for a pressure (left) and temperature (right) curves during cool-down and warm-up of the CT40 (predecessor of CTH40).

8.2 Cleaning

In general the devices do not need any cleaning. To avoid marks on the metal chamber or windows from e.g. fingerprints it can be wiped with a soft lintless cloth moistured with a bit of isopropanol. No abrasive cloth or chemicals should be used.
For the **VSCT40**: The inner part of the valve, in particular the part which is sealed should be kept clean. In case any particles or parts fallen down from a sample have fallen into the valve, the chamber needs to be vented and the valved cleaned. This cleaning depends on the contamination. Small particles can be wiped off by a clean lintless cloth moistured with isopropanol.

9 Performance data

9.1 Cool-down and warm up of VSCT40

Some example data, Fig. 8 for the pressure and temperature measured with the **CTH40** in a **VSCT40**. The chamber had been baked prior to the test. To simulate a typical transfer situation, the chamber had been vented by N_2 and then opened at the DN40 flange for about 10 min – 15 min to air. Then it was closed and pumped for 10 min. with the turbo pump attached directly underneath. Afterwards the cool-down was started. The temperature sensor was placed at the bottom of the cooling body. For this example a pressurized dewar was used to pump LN_2 through the **CTH40**. For warm-up the pressure was released while the system warmed up by itself (no additional action to accelerate warm-up).

9.2 Cool-down and warm up of VSCT40 with the new CTH40 installed

Our new version of CT40, the CTH40, has a heating coil installed inside for fast warm-up. The rest of the functionality is comparable to CT40 while the thermal connection also was improved. The test chamber used was this time electropolished. The data measured with this device can be seen in Fig. 9. A pressure below $1E^{-8}$ mbar can be reached withing 15 min! This is by far the fastest pump-down we've observed.

10 Wiring, cable layouts, temperature conversion

Here the most important technical information is summarized including the cable layouts and the temperature sensor.

10.1 Temperature sensor

Inside the chamber on the sample cooling block or shield a Pt100 resistor (tolerance class A, DIN EN 60751 F 0.15: $0.15 + 0.002 \times |T|$ with T in °C) is mounted. This resistor has a resistance of $100\,\Omega$ at 0 °C and its calibration curve is well known (in °C):

$$R(T) = R_0(1 + A \times T + B \times T^2), \qquad 0°C - 850°C \qquad (1)$$

$$R(T) = R_0(1 + A \times T + B \times T^2 + C \times [T - 100] \times T^3), \qquad -200°C - 0°C \qquad (2)$$

with $R_0 = 100\,\Omega$, $A = 3.9083 \times 10^{-3}$ °C^{-1}, $B = -5.775 \times 10^{-7}$ °C^{-1} and $C = -4.183 \times 10^{-12}$ °C^{-1}. It is nearly linear in the range of interest, the standard resistance-temperature curve for such a sensor is given in Fig. 12.

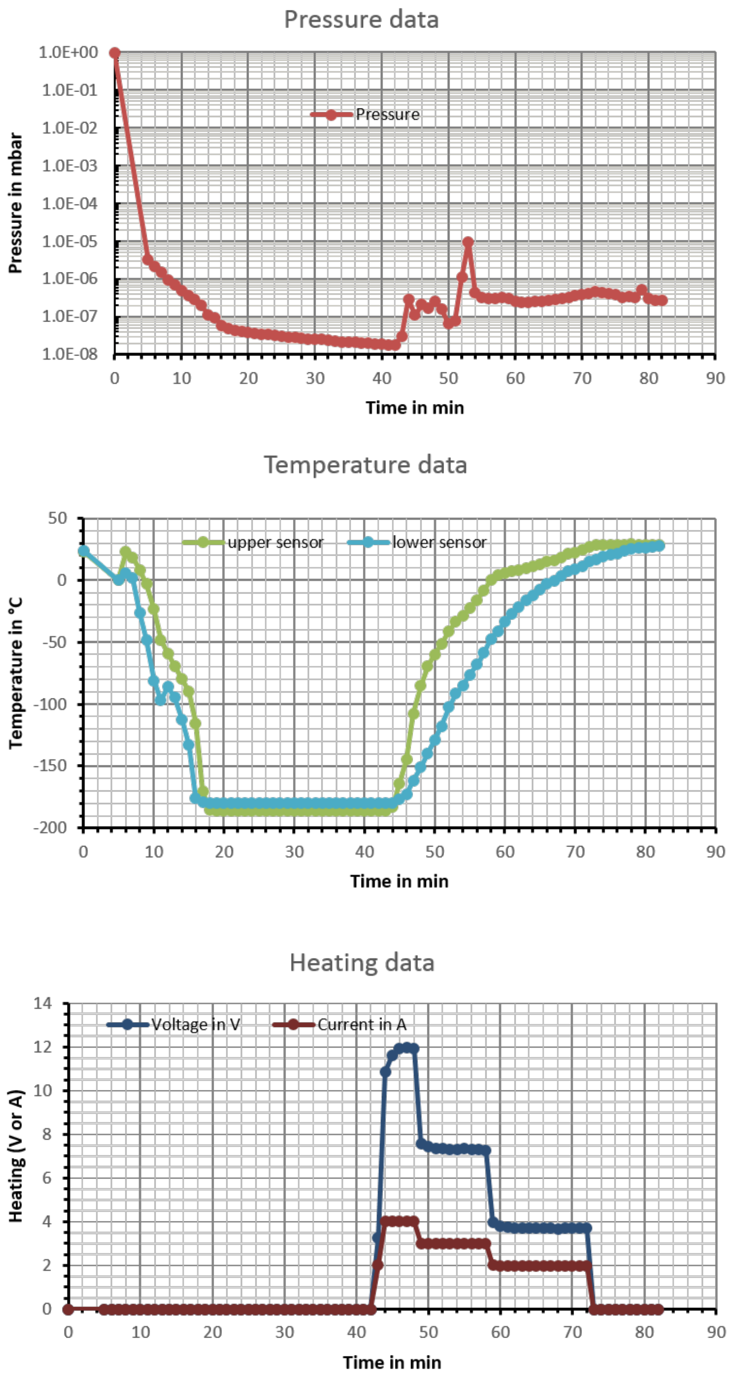
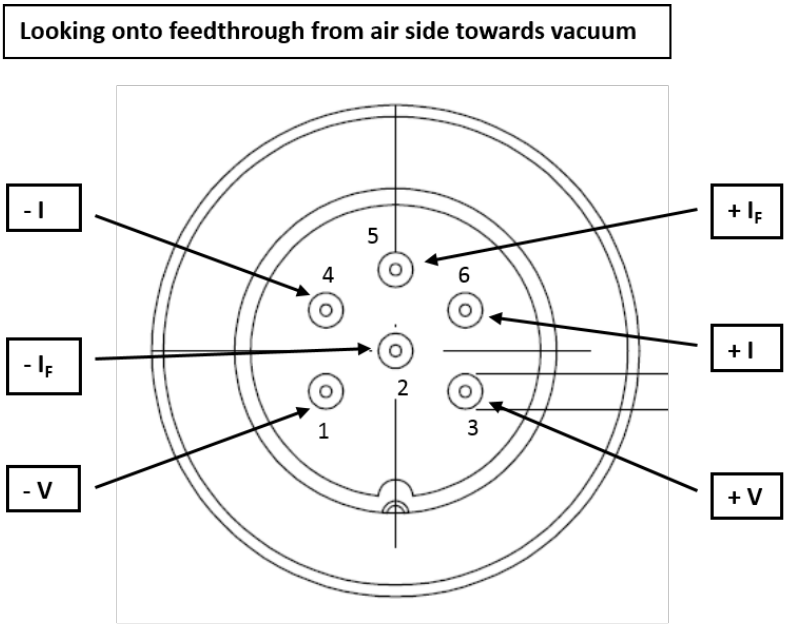


Figure 9: Measurement data taken with a VSCT40 on a typical CF63 turbo pump. On the chamber of the VSCT40 our new **VSCTH40** was installed.



Name	Type	Spec	PIN on Allectra	Notes
- I	Resistor current	About 0.1mA to 10mA	# 4	red
+ I	Resistor current		# 6	yellow
- V	Resistor voltage	About 0.1V to 5.0V	# 1	green
+ V	Resistor voltage		# 3	blue
+ I_F	Filament current	Max. 4.0 A	# 2	
- I_F	Filament current		# 5	

Figure 10: Pin layout for miniature 6-Pin feedthrough for temperature measurement including Pt-Sensor and filament

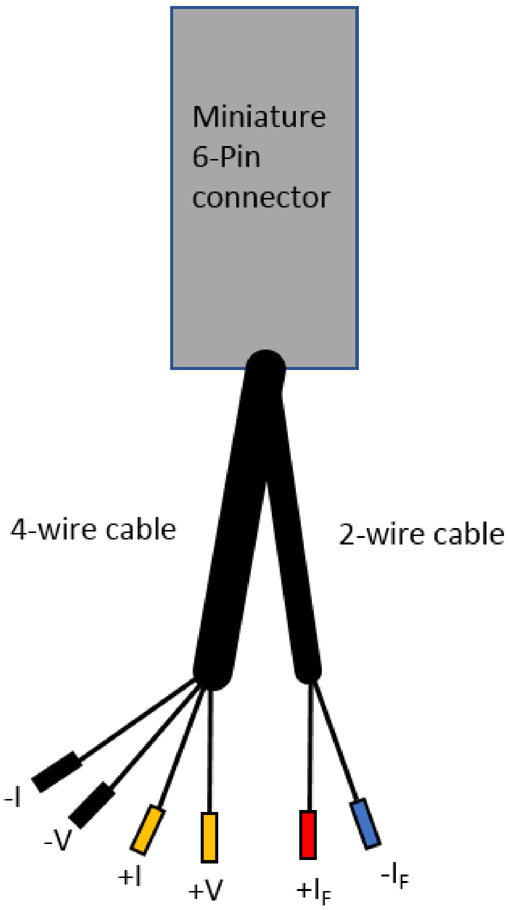


Figure 11: Connection cable layout (CABCTH40HTB4M or CABCTH40HT4M) for temperature measurement including Pt-Sensor and filament. For the temperature sensor 4 wires are available, the heating coil only as 2 wires. For the pin layout of the 6-pin miniature connector please refer to Fig. 10, the pins are connected respectively.

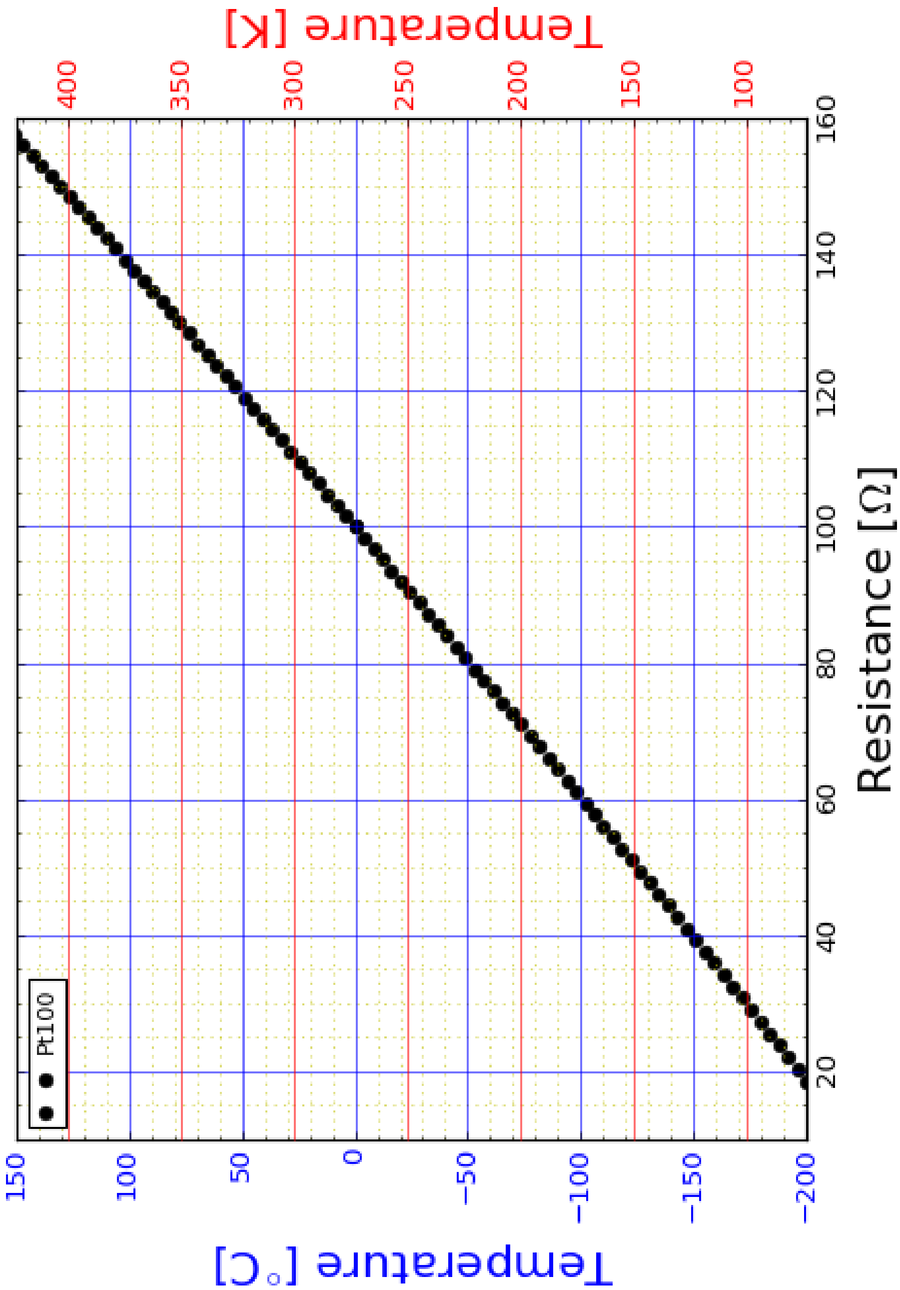


Figure 12: Graphical conversion of resistance into temperature for the Pt100 sensor.

Figure 13: The CT-devices are available with a cable and power supply kit.

11 Upgrades and options

11.1 Configured cabling

Pre-configured cables are available as CABCTH40HT4M or CABCTH40HTB4M while the latter is the bakeable version.

11.2 Kit with cabling and power supply

The devices can also be ordered with configured cabling and a small programmable laboratory power supply. (Temperature measurement device not included.) For temperature measurement a conventional multimeter is sufficient and needs to be supplied by the user.

12 Additional information

12.1 Return of defective items

FERROVAC GMBH will require an **RMA (Return of Materials Authorization) number** and **a complete declaration of contamination** to be issued, before any item is returned to us. Please contact us therefore. You will be given an RMA number and information on how to proceed with the return of your defective items.

12.2 Download

This manual can be downloaded from our website VSCT40. It can be found in the specifications of the **CTH40** or **VSCT40**.
For any suggestions or questions considering this manual, please contact us and write an e-mail to sales@ferrovac.com.