OPERATING INSTRUCTIONS
CAPNOGRAPH TYPE 340

Version 2.01E dated 16.07.2012
RZ

Contents

1. Introduction, manufacturer's details

These Operating Instructions describe the function and use of the Capnograph Type 340.

The information in these Instructions has been drawn up after careful examination but does not represent a warranty of product properties. Alterations in line with technical progress are reserved.

Manufacturer's Address:
HUGO SACHS ELEKTRONIK - HARVARD APPARATUS GmbH
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Internet: www.hugo-sachs.de or www.harvardappartus.com

1.1 Copyright

2. Safety notes Warning:

- Do not supply explosive gases to the Capnograph - DANGER !
- Be careful when working with aerosols, gases and gas mixtures. Connect the outlet to the exhaust.
- Before you supply aerosol, gases or gas mixtures to the Capnograph check all connections carefully.
- The Capnograph is designed for use in general laboratories, light industrial and office environments.

3. General description, application

The Capnograph has been developed specially for the measurement of the Endexpiratory CO2 concentration in expired air of rodents as well as respiratory parameters. The Capnograph consists of main instrument, with display, which measures End Tidal CO2 (ETCO2) concentration in the expired air. With the addition of the Tracheal Pressure and Air Flow sensor, repiratory parameters such as peak inspiratory- (PIF), peak expiratory- (PEF) flow, Tidal Volume (TV), respiratory rate (RR) and peak tracheal pressure (TP) can be measured.

3.1 Principle of operation

This instrument uses a built in infrared sensor for CO2 measurement.

The Tracheal Pressure and Air Flow sensor (later named TP/AF sensor) consits of an integrated pneumotachometer with a differential pressure sensor, as well as a pressure sensor for the tracheal pressure.

Airflow, Tracheal pressure and CO2 are available as phasic signals on the respective analog BNC-outputs. ETCO2, tidal volume and respiratory rate are available as mean analog signals (calculated average over three breaths) on the respective BNC-outputs.

4. Technical description

4.1 Capnograph main Instrument

The Capnograph is built in a metallic case. A LCD display located on the top of the case displays parameters graphically and numerically. The key pad for programming the instrument is also located on the top.

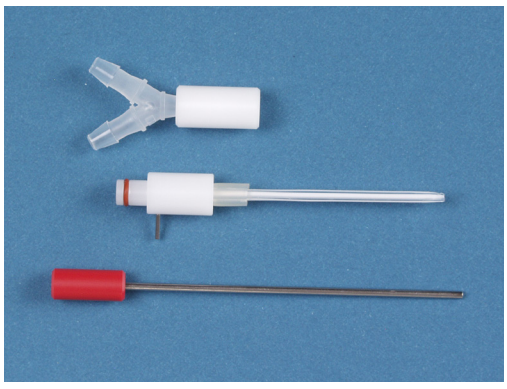
Located on the front panel are the Input connectors for the TP/AF sensor and the input port for the CO2 sensor. The BNC-outputs for the phasic analog signals for respiratory flow and tracheal pressure are also located on the front panel.

Located on the back panel you will find the power input, the analog BNC-Outputs for the CO2 phasic signal, the ETCO2, the RRate and the TV analog signals. Also located on the back panel is an outflow port for air or gas mixture that has passed over the CO2 sensor.

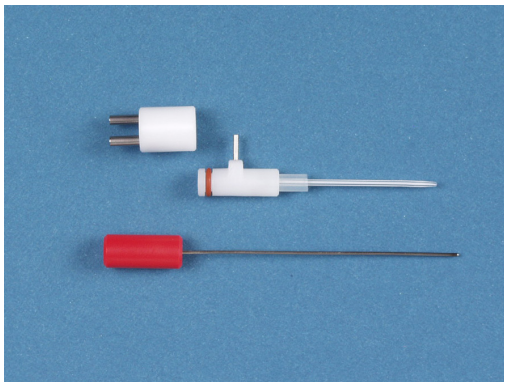
The unit comes with the standard accessory kit consisting of:
- the instruction manual
- the power cord
- 3 BNC-BNC cables
- the CO2 tubing set for Capnograph Ref: 73-4164. The tubing set is equipped with a segment of Nafion® tubing for drying the air going to the CO2 sensor. If you replace the tubing by a regular PE-tubing you may get humidity into the sensor and get a failure.

In addition there are two optional cannulating kits available:

Ref: 73-4165
Rat cannulating kit to Capnograph with adapter for ventilator

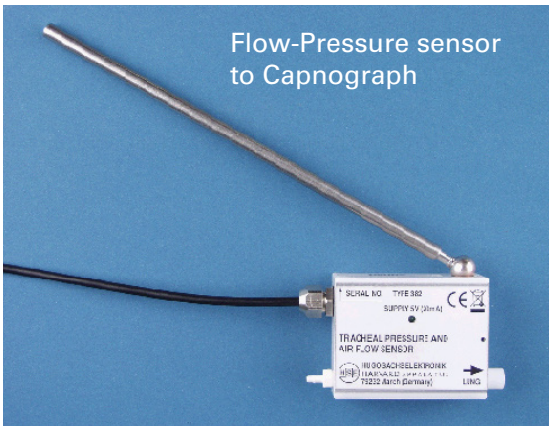


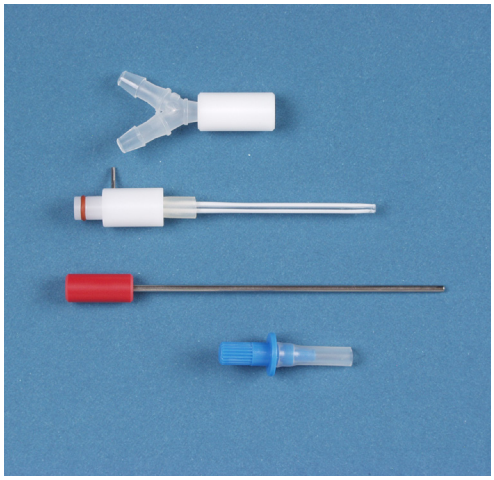
Ref: 73-4166
Mouse cannulating kit to Capnograph with adapter for ventilator



Further available options:
- Flow-Pressure sensor for Rat to Capnograph
  Ref: 73-3817
- Flow-Pressure sensor for Mouse to Capnograph
  Ref: 73-3816

The Flow-Pressure sensor includes the sensor itself with in addition the adapted cannulating kit, the calibration stopper all in an accessory box



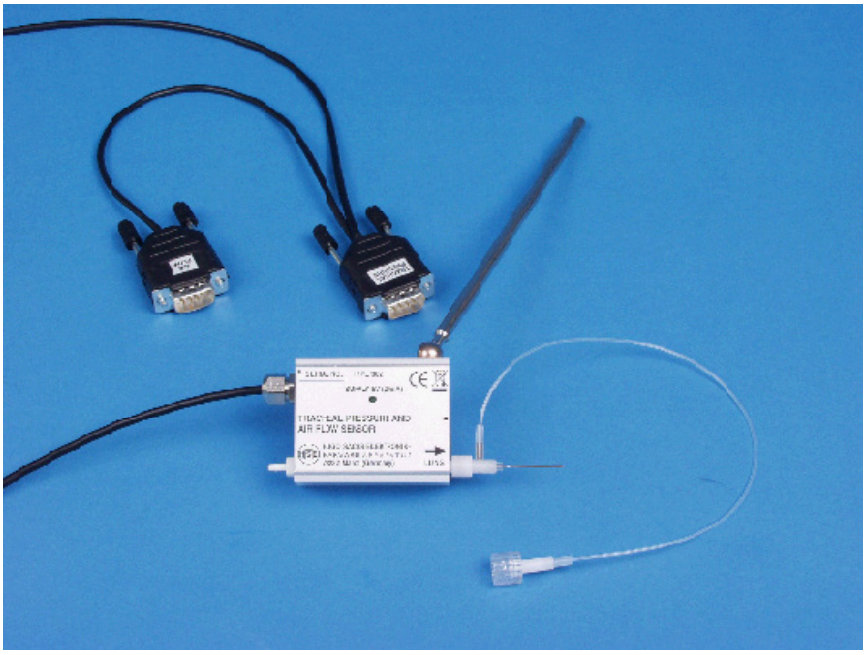


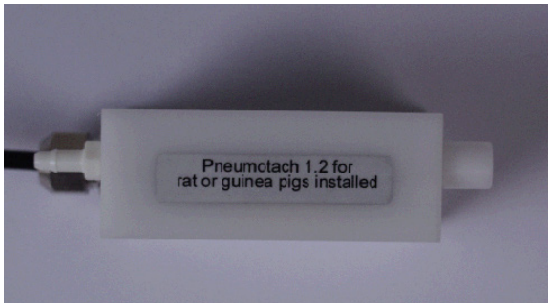
Cannulating kit with stopper

Accessory box

4.2 Tracheal Pressure and Air Flow Sensor

This sensor unit includes a pneumotachometer, a differential pressure transducer for measuring respiratory airflow, as well as a pressure transducer for measuring Tracheal Pressure. The sensor is connected via a cable and two connectors to the main capnograph unit. The sensor is a flow through sensor. A tracheal or intubation cannula is connected to the sensor to ensure low dead space volume. A magnetic ball with bar allows easy mounting on a stand using an X-Block.

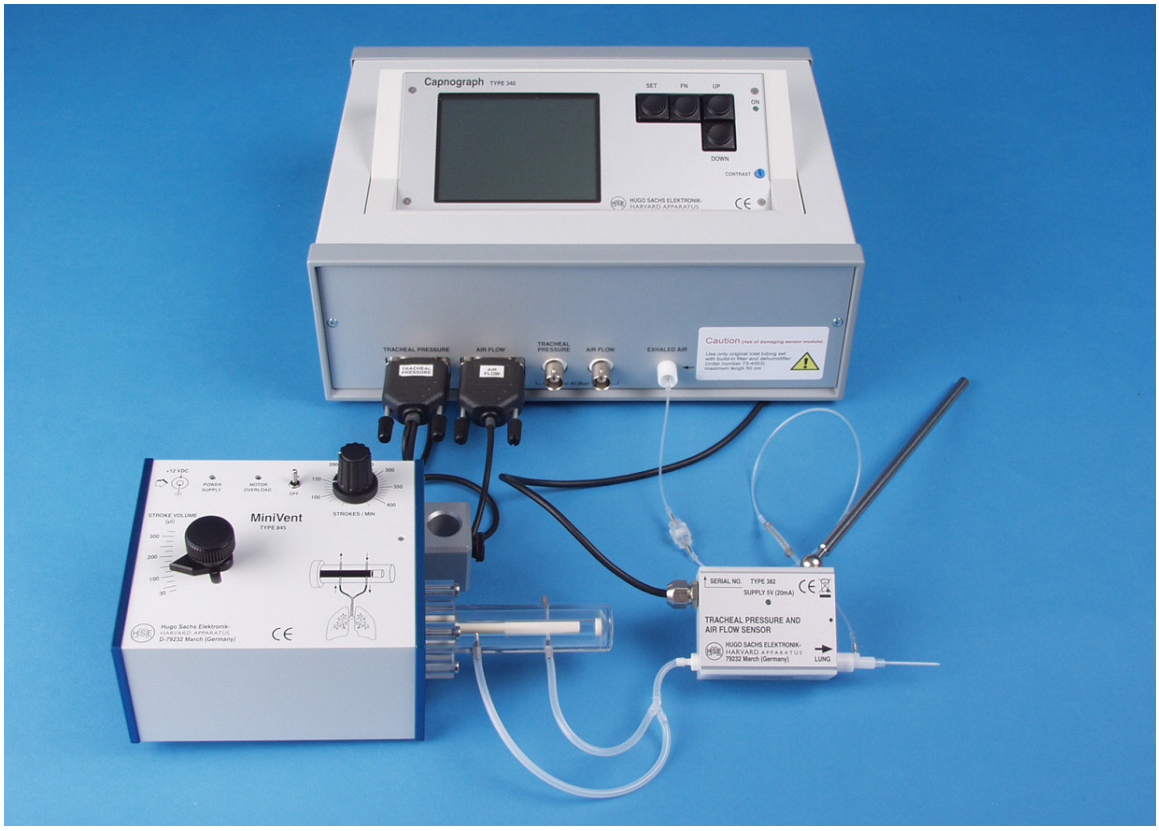




See the label on the side of the sensor to differenciate for species:
- Mouse
- Rat GuineaPig

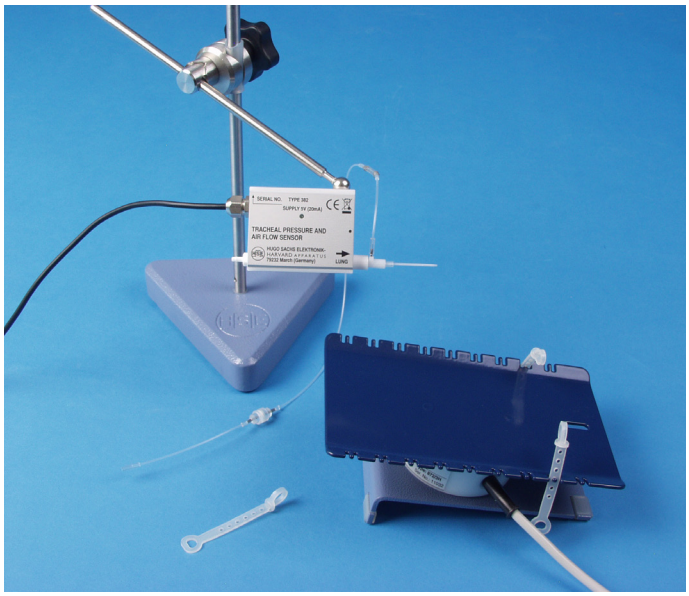
Capnograph without TP/AF sesnor and a Minivent to be connected to a mouse for a ventilated application.

Same as above but with TP/AF sensor connected to the Capnograph and a Minivent to be connected to a mouse for a ventilated application.



TP/AF sensor connected to the Capnograph without ventilator to be connected to a mouse for a non-ventilated application.

TP/AF sensor mounted on a rod to be connected to an anesthetized, non-ventilated animal.



TP/AF sensor mounted on a rod placed next an operating table to be connected to an anesthetized, non-ventilated mouse.

5. Components and arrangement of the apparatus

5.1 Components

The working system consists of the following units:
- Capnograph main unit

In addition (Option):
- The Airflow and Tracheal Pressure Sensor for Mice
- The Airflow and Tracheal Pressure Sensor for Rats

5.2 Arrangement

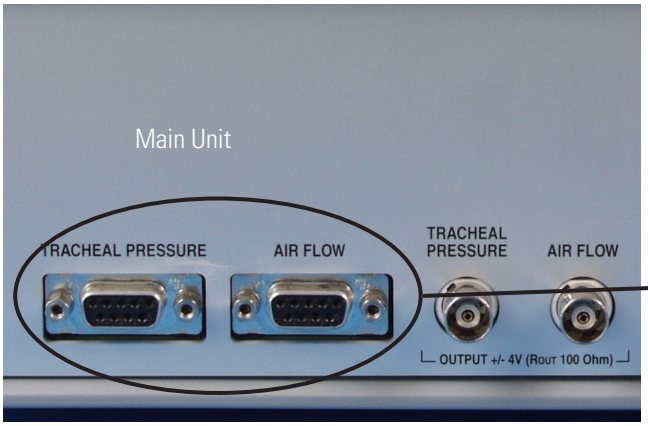
A number of conditions must be fulfilled when setting up the apparatus. In particular, keep in mind that some experiments involve the presence of anesthetic gases, other gas mixtures as well as regular room air. The respiratory air flow may be a gas mixture and contain anesthetics, in this case the outlet of the Capnograph must be evacuated.

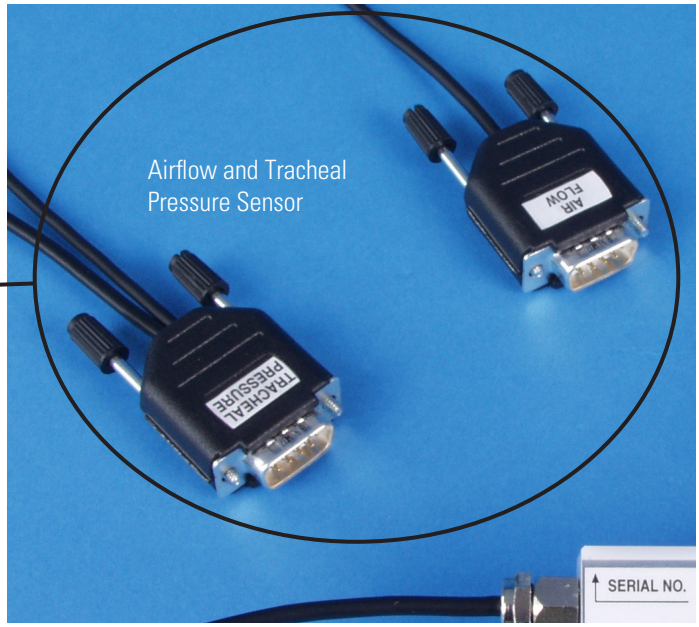
The room should be equipped as follows:
- Fume cupboard (possibly with filter, depending on the substances being used) or at least an evacuation system, or
- An anesthetics scavenging system

6. Assembling the apparatus

6.1 Sensor and main Capnograph Unit with display

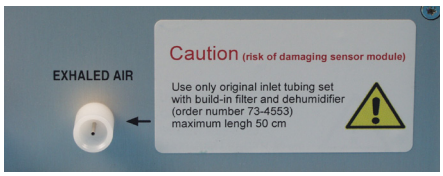
The unit is delivered disassembled. The TP/AF sensor must be connected to the main unit. Two labelled connectors, one for the Airflow sensor and one for the Tracheal Pressure sensor, are located on the sensor. These sensor connectors must be connected to the ports on the front panel of the main unit. These ports are also labelled.



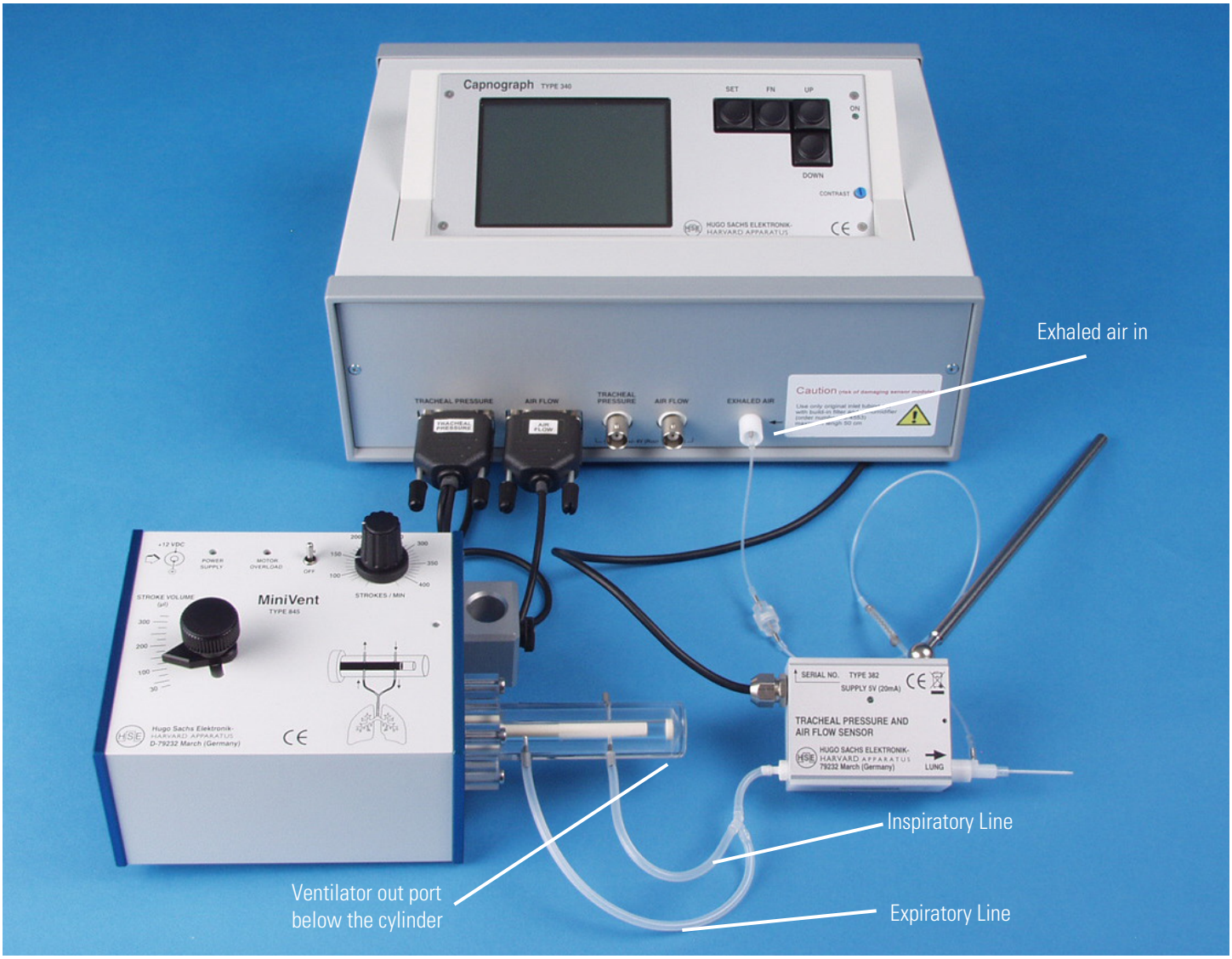


6.2 Connection of the CO2 Sensor

The CO2 sensor is built in the main unit. The sensor port on the Main Unit labelled “Exhaled Air” is coneected via the delivered tubing to the side port of the cannula holder (see the images on the next page). The tubing fitting to the port has been designed to have a low dead volume. Do not use any regular Luer-lock tubing fitting which would increase the dead volume and end up with wrong CO2 measurement. The sampling volume is ~15ml/min!



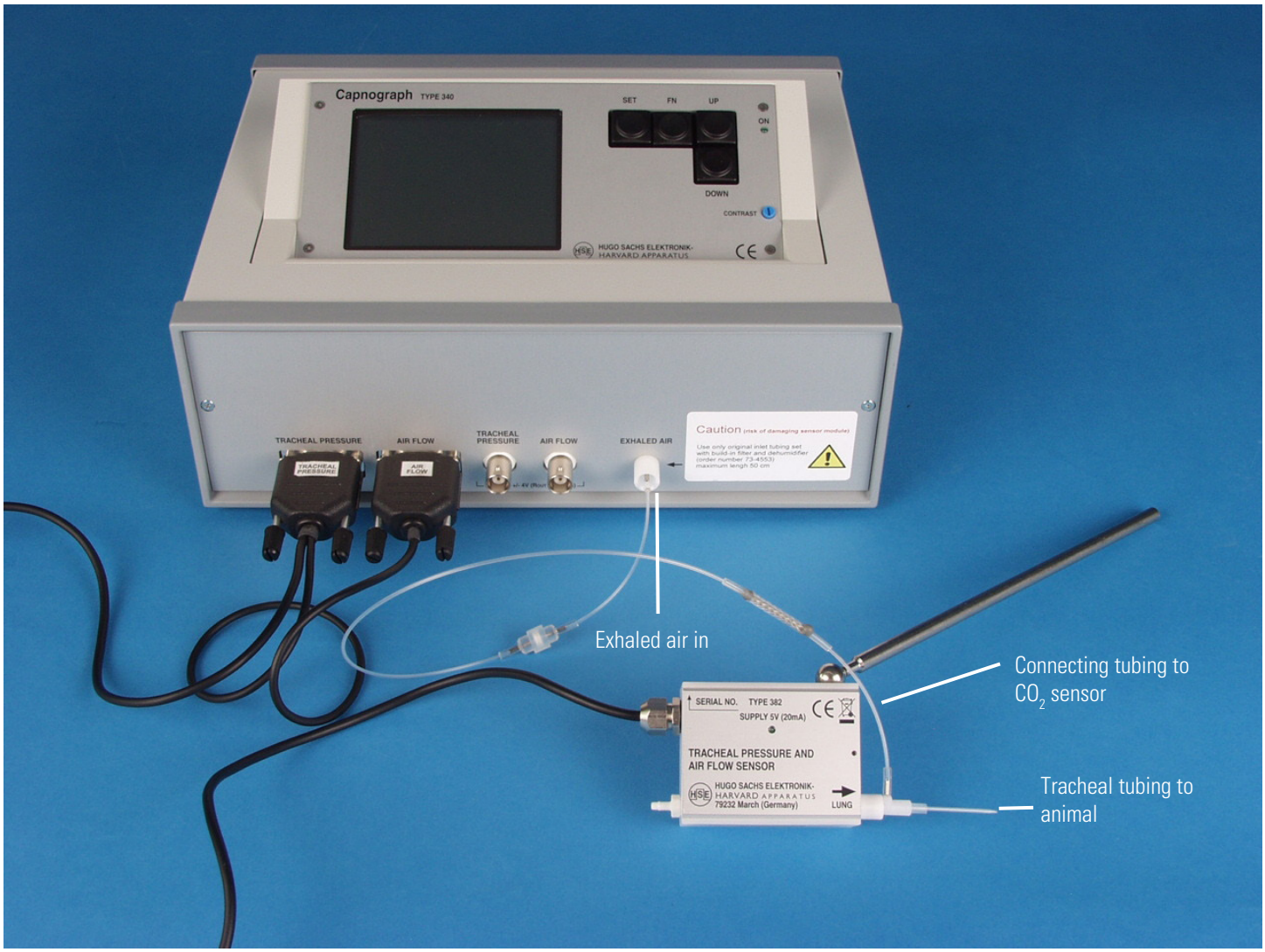
6.2.1 Connection of a ventilated animal



The tubing in between the “Exhaled Air” port and the animal is connected to the side port of the cannula holder. A constant flow of 15ml/min is withdrawed and supplies the built in CO2 sensor with the expired air. The port on the cannula holder is placed in front of the TP/AF sensor, it withdraws air from the tracheal or intubation canuula, resulting in less ventilation volume as set on the ventilator for the animal. For a proper measurement of the respiratory parameters, it is important to correct the ventilator for the volume withdrawn (see the corresponding function described later).

PE20 polyethylen tubing is used for the connection. To optimize the response of the CO2 sensor it is important to keep the dead volume low. We recommend the Unit to be as near as possible to the animal so the shortest possible tubing can be used. The maximum tubing length is 50cm. Again the fitting connecting the tubing to the port on the main unit is a special design, never use a standard Luer-Lock tubing fitting.

6.2.2 Connection of a non-ventilated animal



The tubing between the “Exhaled Air” port and the animal is connected to the side port on the cannula holder.

PE20 polyethylen tubing is used for the connection. To optimize the response of the CO2 sensor it is important to keep the dead volume low. We recommend placing the Unit as near as possible to the animal so the shortest possible tubing can be used. Maximum tubing length 50 cm.

6.2.3 Cannula mounting for mouse

The cannula holder is removed from the TP/AF sensor by pulling out. The tubing connection to the CO2 sensor port can be disconnected from that port and remain connected to the holder, or vice versa.

Different types of cannulae can be used. The standard HSE-Harvard Stainless steel intubation cannula available in several sizes (Figure A), or the commercialy available Vasofix® ("Braunüle") or Introcan® (Figure B)

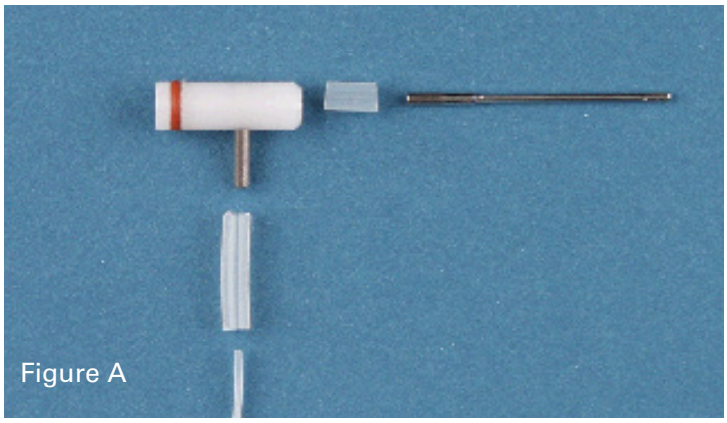


Figure A

Available Stainless steel cannulae:

73-0029	OD = 1.0mm
73-2825	OD = 1.2mm
73-0028	OD = 1.3mm

The Vasofix® or Introcan® are available in diameters of diameter of 14, 16, 17, 18, 20, 22, 24G

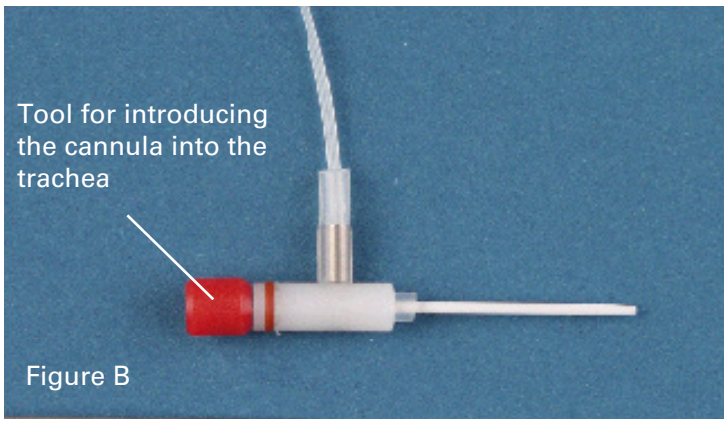
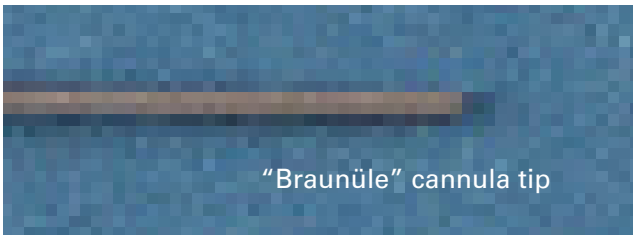


Figure B

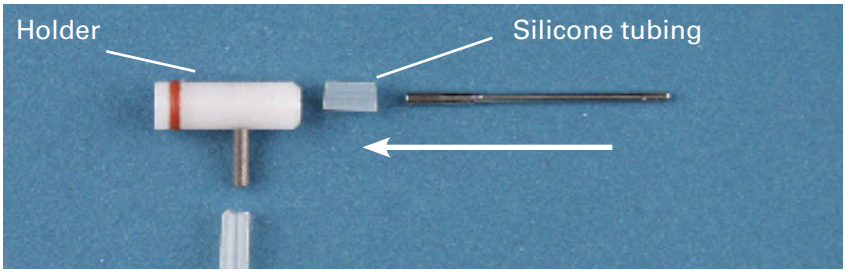
The main differences are the tips, the flexibility and the available sizes.
The stainless steel cannulae have a rounded tip to ensure better sealing.The stainless steel is rigid and does not require a special tool for introduction. The rigidity allows to have less wall tickness and therefore a larger ID by the same OD and finaly less flow resistance.

The Vasofix® or Introcan® have a conic tip. They are more flexible but but don't seal as well and require a special tool (wire) for the placement into the trachea. The tool is supplied with the cannula holder.



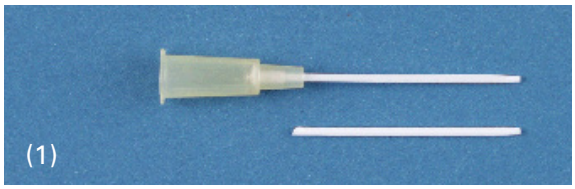
The cannula is mounted on the holder using a silicone tubing. For mounting the cannula, the silicone tubing is first installed in the holder.

For the stainless steel cannulae the cannula is pressed into the silicone tubing.

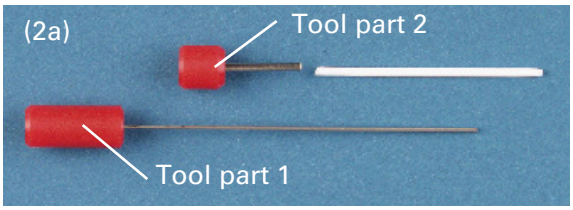


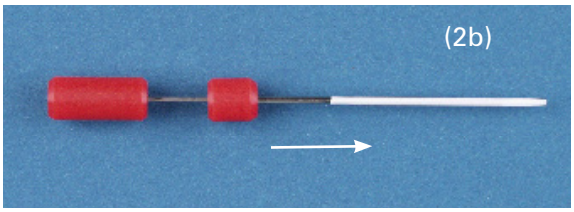
For the Vasofix® or Introcan® :

- The tip is first cut (1)

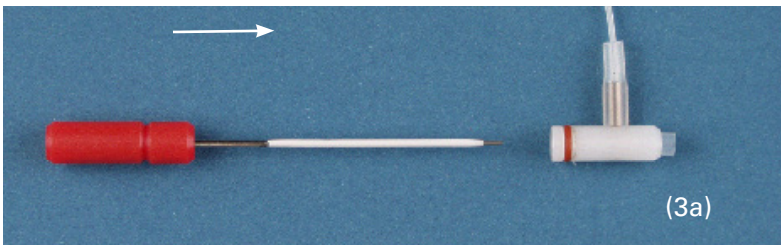


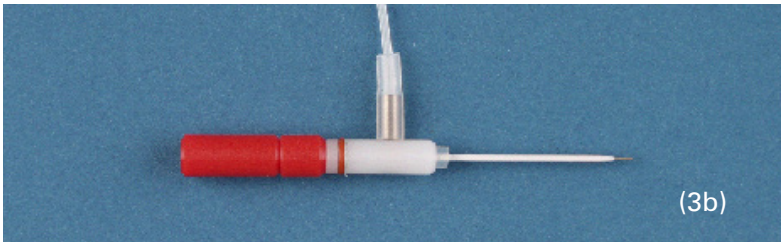
- The tip is mounted on the special tool (2a +2b). The tools consists of two parts. Part 1 is the guide wire for the cannula introduction into the trachea, Part 2 is used to place the cannula into the holder. To mount the tip first mount the tool by introducing Part 1 into Part 2 then place the tip on Part 1 all the way to the stop of Part 2





- Using the introduction tool the tip is introduced from the back into the holder (3a +3b)





6.2.4 Cannula mounting for rat or guinea pig

The cannula holder is removed from the TP/AF sensor by pulling out. The tubing connection to the CO2 sensor port can be disconnected from that port and remain connected to the holder, or vice versa.

Different types of cannulae can be used. The standard HSE-Harvard Stainless steel intubation cannula available in several sizes (Figure A), or the commercialy available Vasofix® ("Braunüle") or Introcan® (Figure B)

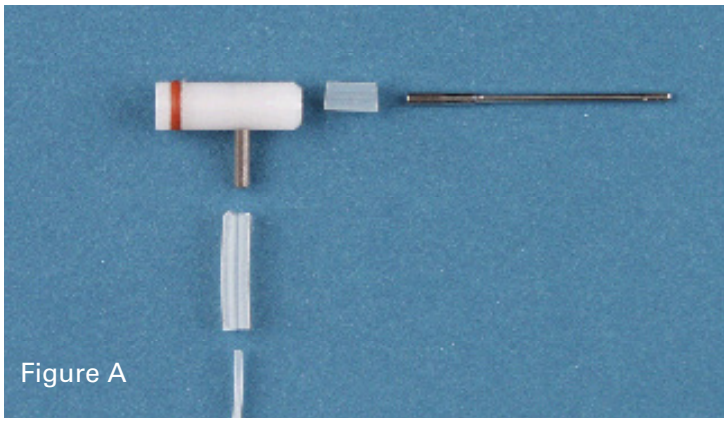


Figure A

Available Stainless steel cannulae:

73-2826	OD = 1.5mm
73-2827	OD = 1.8mm
73-2828	OD = 2.0mm
73-2829	OD = 2.3mm
73-0033	OD = 2.5mm

The Vasofix® or Introcan® are available in diameters of diameter of 14, 16, 17, 18, 20, 22, 24G

The main differences are the tips, the flexibility and the available sizes.
The stainless steel cannulae have a rounded tip to ensure better sealing.The stainless steel is rigid and does not require a special tool for introduction. The rigidity allows to have less wall tickness and therefore a larger ID by the same OD and finaly less flow resistance.

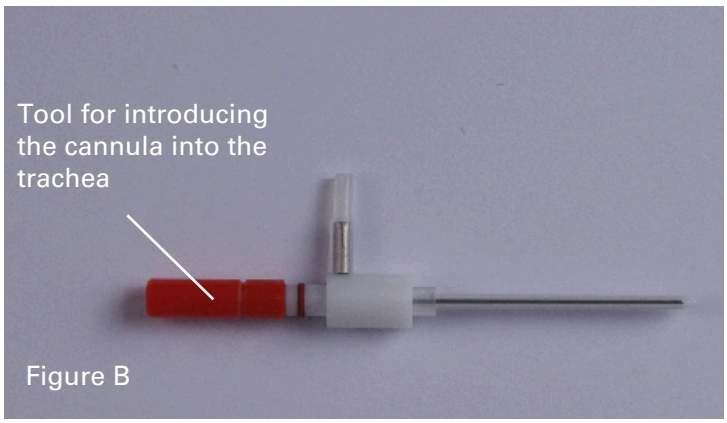
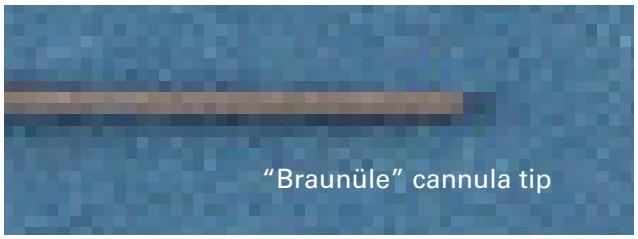


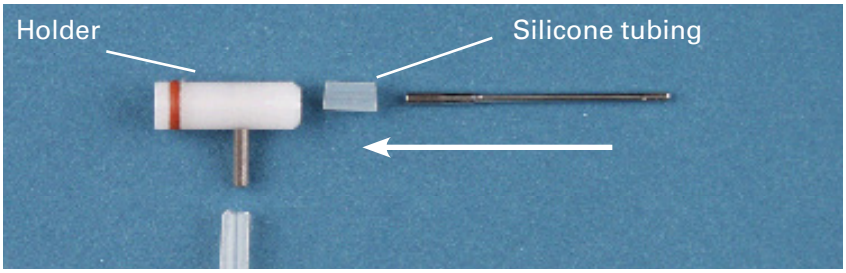
Figure B

The Vasofix® or Introcan® have a conic tip. They are more flexible but but don't seal as well and require a special tool (wire) for the placement into the trachea. The tool is supplied with the cannula holder.



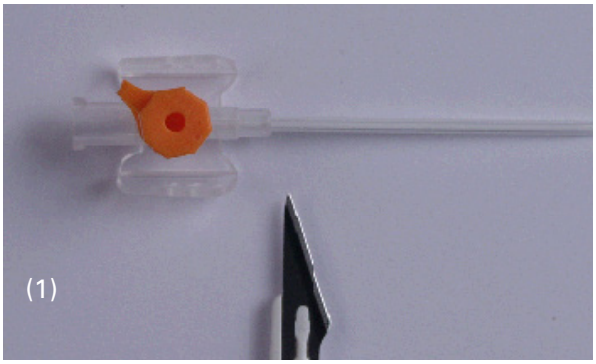
The cannula is mounted on the holder using a silicone tubing. For mounting the cannula, the silicone tubing is first installed in the holder.

For the stainless steel cannulae the cannula is pressed into the silicone tubing.

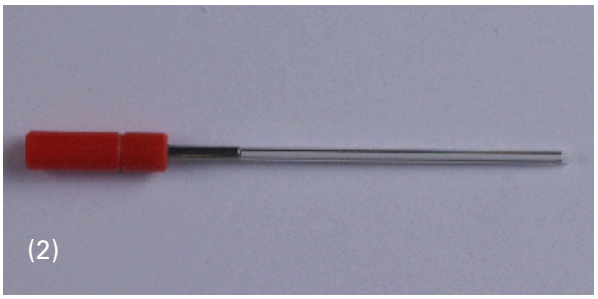


For the Vasofix® or Introcan® :

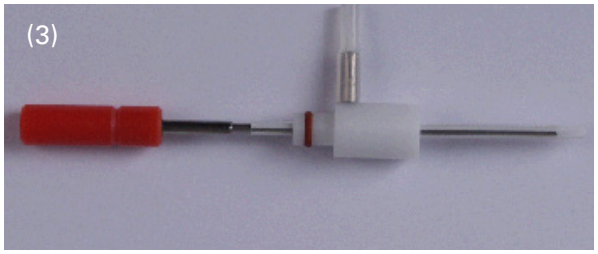
- The tip is first cut (1)



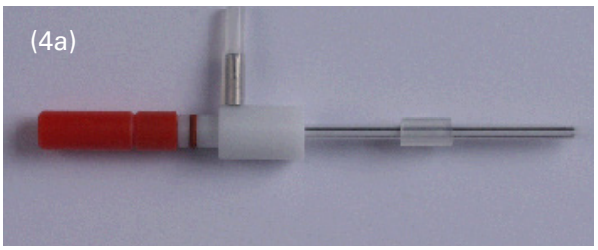
- The tip is mounted on the special tool. The tool consists of two parts. Part 1 is the guide wire for the cannula introduction into the trachea, Part 2 is used to place the cannula into the holder. To mount the tip first mount the tool by introducing Part 1 into Part 2 then place the tip on Part 1 all the way to the stop of Part 2



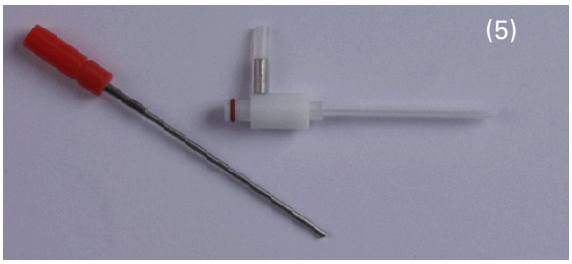
- Using the introduction tool the tip is introduced from the back into the holder (3)

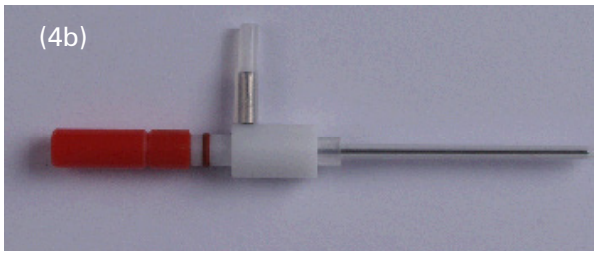


- Place the sealing silicone tube over the tip and push it down to the cannula holder, push it inot the holder to seal the cannula (4a +4b)



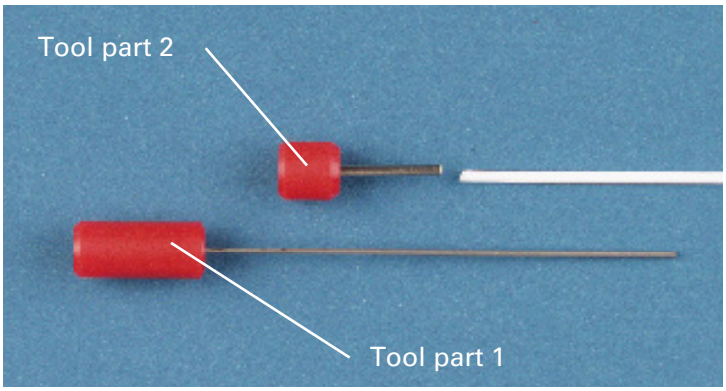
- Remove the tool (5)

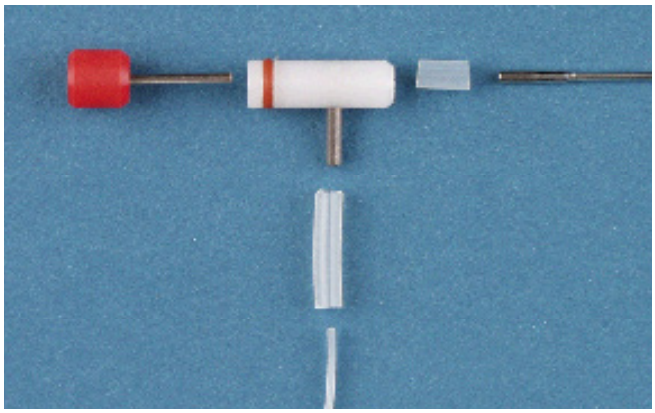




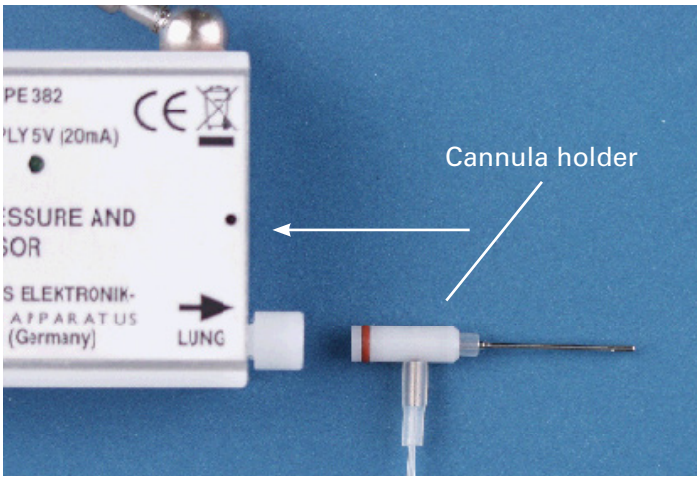
6.2.5 Introducing the mouse Cannula and connecting

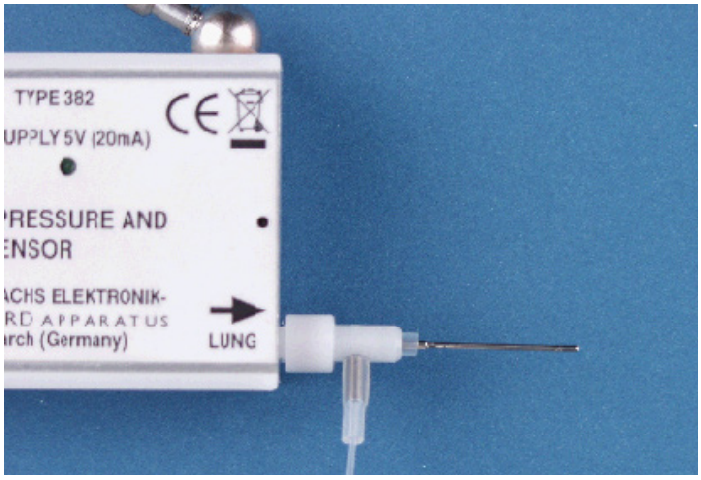
The cannula is introduced into the trachea according know techniques, on a slope XXXX with the help of a cold light lamp. Once the cannula is placed and if the introducer tool has been used, the internal mandrin Part 1 is removed to allow the animal to breath. The connecting tubing is connected to the holder, Part 2 of the tool avoids that the tubing is introduced to deep into the holder. Once the tubing is in, the Part 2 of the tool is removed and the holder is place into the TP/AF sensor or the ventilator tubing connector. For stainless steel cannula only the Part 2 of the tool is used to arrest the tubing when it is connected to the holder.



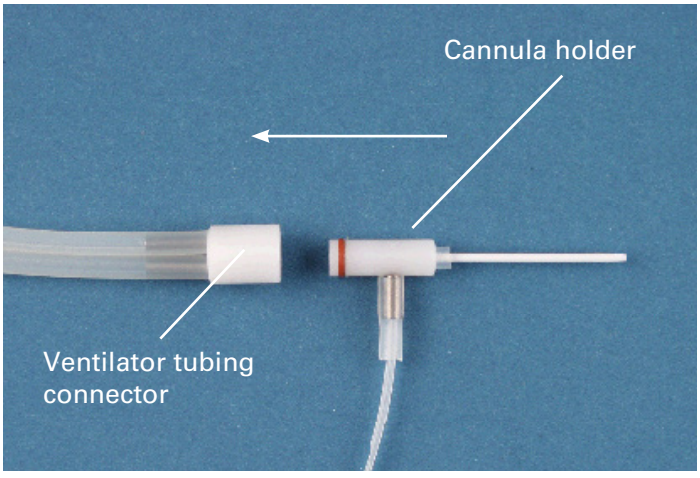


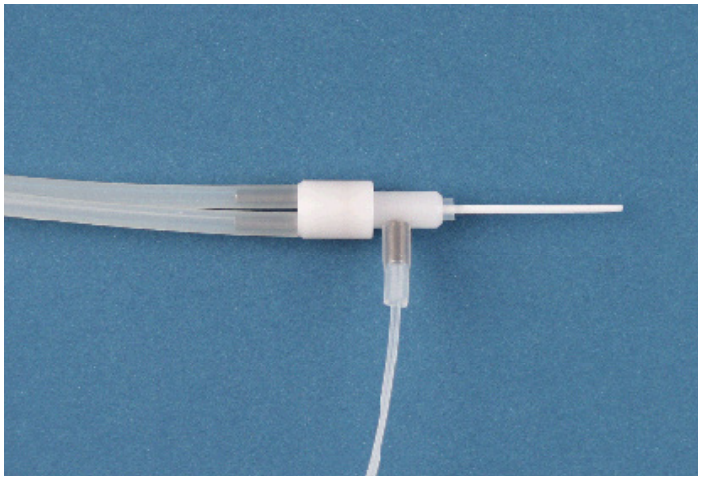
Mounting the holder on the TP/AF sensor





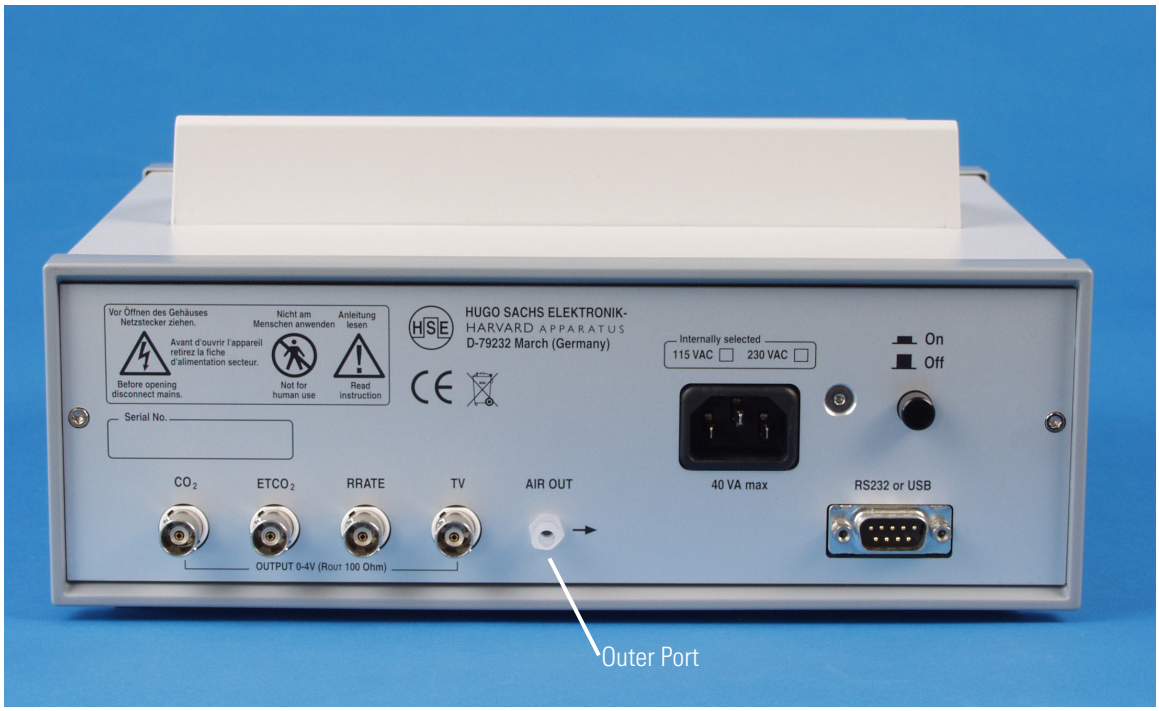
Mounting the ventilator tubing connector





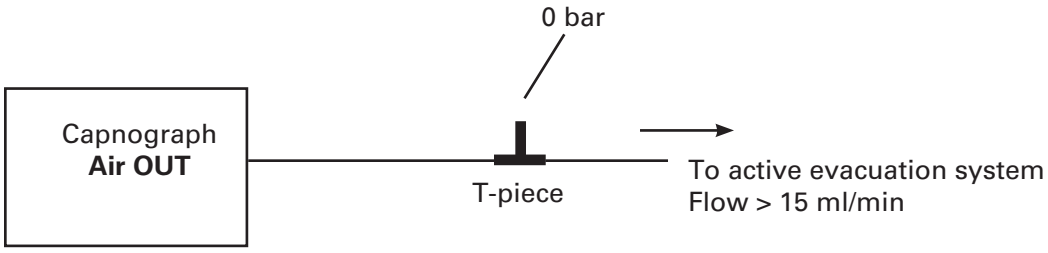
6.3 Connection of the CO2 sensor outflow

The outlet port is on the rear of the main unit.
A constant flow ~ 15 ml/mindraws air through the CO2 sensor. The outlet must be connected to a scavenging system or any other evacuation system if anesthetic products or gas mixtures are used for the ventilation. It is essential to first check whether or not the extraction system is designed and approved for handling the substances used.



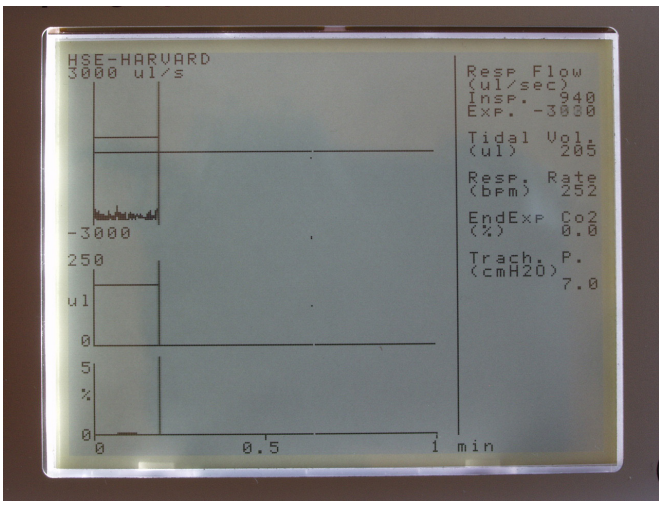
DANGER:	Anesthetics or gas mixtures used for ventilation present a danger for the experimentator if not evacuated properly. Take care to use reliable evacuation systems and methods.

If an evacuation or scavenging system is connected, it is important that the connection be pressure free. The evacuation system should not generate any negative pressure at the outlet port. If the flow of the evacuation system is too high, a pressure neutral (equilibrated bypass must be installed using a T-piece and tubing.



7. How to use the Capnograph

After all connections are made, switch on the Capnograph. The power switch is located on the back panel.The initialization of the unit takes a few seconds until the main Window is shown on the display. The window displayed depends on the configuration of the system.

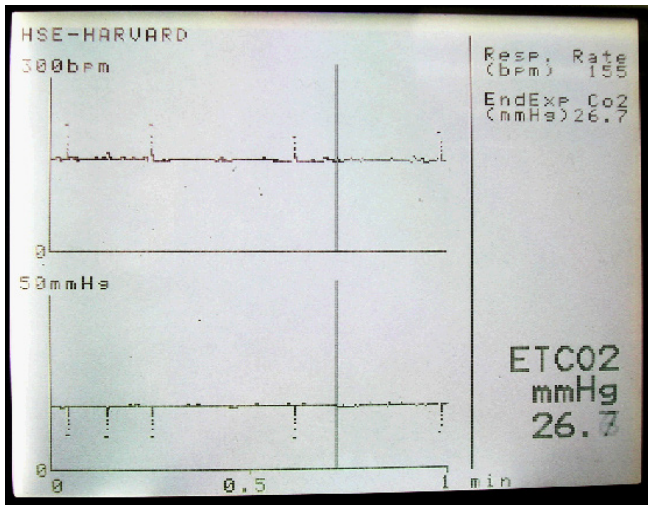


If the TP/AF sensor is connected, the right side of the display will show the evaluated parameters, such as:

- Maximum Inspiratory Flow
- Maximum Expiratory Flow
- Tidal Volume
- Respiratory Rate
- Endexpiratory CO2
- Maximum Tracheal Pressure

On the left side, the display will show the trend of the parameters graphically. The time scale default for the graph is 30 minutes for the first time the machine is used.

Time scale can be changed (see later)



If the system uses no Air Flow Tracheal Pressure sensor, the right side of the display shows different evaluated parameters, such as:

- Respiratory Rate
- Endexpiratory CO2

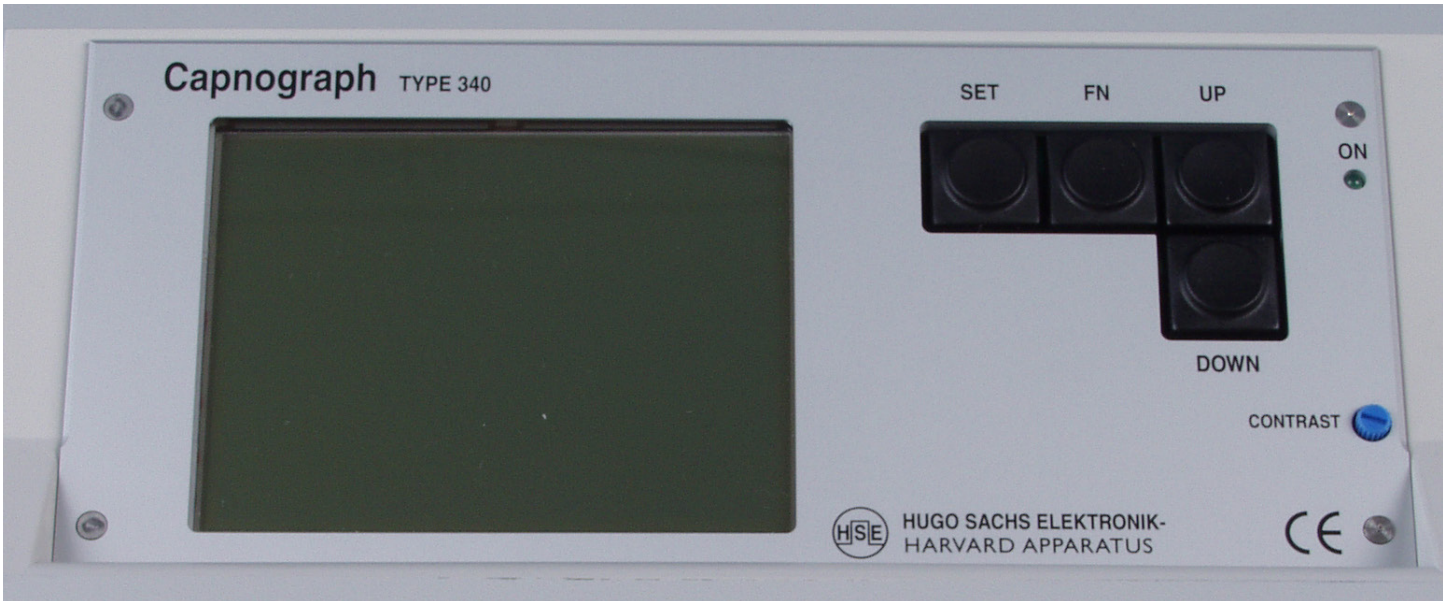
On the left side, the display shows the trend of the parameters graphically. The time scale default for the graph is 30 minutes for the first time the machine is used.

Time scale can be changed (see later)

If the animal is connected to the cannula, measurement starts immediately.

The analog signals for flow and pressure are immediatly available on the corresponding BNC-Outputs on the front panel. If the unit has no TP/AF sensor connected, the corresponding analog outputs must be ignored.

7.1 The display and control functions



Right to the display there are four keys allowing the control and the setup of the main unit.
The keys are labelled:
- SET
- FN
- UP
- DOWN

A potentiometer labelled “CONTRAST” is used to set the contrast of the display depending on the ambient temperature and light. If the display is white or black, use the potentiometer to achieve the correct contrast.

The LED “ON” indicates that the power is on.

The “FN” key is used to enter the different settings to control the functions of the unit, such as
- Scaling of signals
- Calibration
- Setup the graphic screens appearance
- Side stream Compensation
- Signal output calibration

The “UP” and “DOWN” keys are used for selection, and the “SET” key for confirmation of the selection.

During the normal running mode (no function selected) the “UP” and “DOWN” key allow you to modify the time scale (X-Axis) of the display.

7.2 Changing the graph Time scale (X-axis)

The first time the system is switched on, the X-Axis time scale is set to 30 Minutes. On the next power-on sequence, the previous setting is read in from the internal memory. Pressing the “DOWN“ key will decrease the time scale Pressing the “UP“ key will increase it. The available selections are:
- 1 Minute
- 3 Minutes
- 15 Minutes
- 30 Minutes

The actual setting is stored in the internal memory and recalled the next time the unit is powered-up.

7.3 The function mode

By pressing the “FN” key, the system enters the function mode. The following functions are available:

- **Scaling**
- **Calibration**
- **Display**
- **Flow Compensation**
- **Output Calibration**

By pressing the “FN” key, the first option is shown on the screen

Function SCALING
Press <Fn> for next function
Press <SET> to proceed

By pressing the “FN” key again, the system jumps to the next option

Function CALIBRATION
Press <Fn> for next function
Press <SET> to proceed

By pressing the “FN” key again, the system jumps to the next option

Function DISPLAY
Press <Fn> for next function
Press <SET> to proceed

By pressing the “FN” key again, the system jumps to the next option

Function FLOW COMPENSATION
Press <Fn> for next function
Press <SET> to proceed

By pressing the “FN” key again, the system jumps to the next option

Function OUTPUT CALIBRATION
Press <Fn> for next function
Press <SET> to proceed

and so on. By pressing only the key “FN” the system, after having shown all the options, comes back to the normal display without any changes.

Pressing the “SET” key will allow you to enter the respective function.

7.3.1 Function Scaling

The function scaling allows the scaling of the Y-Axis so that the parameters will be displayed graphically. Depending on the configuration of the system (with or without TP/AF sensor), this function will allow you to select the Y-Axis scaling for each parameter, except for the respiratory rate where the scaling is fixed. After having entered the function with the "SET" key, the display will show:

Co2 scaling = XXX nn
Press <Fn> for next parameter
Press <SET> to proceed

XXX means the actual setting, nn means the actual unit as the CO2 value can be expressed in mmHg or in % . Pressing the "UP" or "DOWN" key will allow you to toggle through the proposed settings:
- 5 %
- 10 %
- 15 mmHg
- 25 mmHg

Pressing the "SET" key will confirm the selection. Pressing the "FN" key will skip to the next parameter keeping the previous setting.

If no TP/AF sensor is used, you will exit the scaling function. If the sensor is present, the following parameters can be scaled:

In case of a mouse sensor

Airflow scaling = XXXX ul/sec
Press <Fn> for next parameter
Press <SET> to proceed

XXXX means the actual setting. Pressing the "UP" or "DOWN" key will allow you to toggle through the proposed settings:
- 2000 ul/sec
- 3000 ul/sec

In case of a rat guinea pig sensor

Airflow scaling = XXX ml/sec
Press <Fn> for next parameter
Press <SET> to proceed

XXXX means the actual setting. Pressing the "UP" or "DOWN" key will allow you to toggle through the proposed settings:
- 20.0 ml/sec
- 30.0 ml/sec

In case of a mouse sensor

Tidal Volume = XXX ul
Press <Fn> for next parameter
Press <SET> to proceed

XXX means the actual setting. Pressing the "UP" or "DOWN" key will allow you to toggle through the proposed settings:
- 250 ul
- 500 ul

In case of a rat guinea pig sensor

Tidal Volume = XXX ml
Press <Fn> for next parameter
Press <SET> to proceed

XXX means the actual setting. Pressing the “UP” or “DOWN” key will allow you to toggle through the proposed settings:
- 2.5 ml
- 5.0 ml

Tracheal Pressure scaling = XX cmH2O
Press <Fn> for next parameter
Press <SET> to proceed

XX means the actual setting. Pressing the “UP” or “DOWN” key will allow you to toggle through the proposed settings:
- 25 cmH2O
- 50 cmH2O

After the last parameter, the system returns to the function menu and passes to the next menu item which is “calibration”

7.3.2 Function Calibration

The unit is factory calibrated and ready to be used. There is no reason for calibrating the unit every day. Measurement of CO_2 is temperature and atmospheric pressure compensated.

The function calibration allows to calibrate physically each measured signal depending on the configuration of the system (with or without the Air Flow Tracheal Pressure sensor). The calibration is in two steps, first the baseline and secondly the calibration value. After having entered the function with the "SET" key, the display will show:

Set all to 0 (ul/sec, cmH2O, %)
Press <Fn> for next parameter
Press <SET> to proceed

You are prompted to set all signals to the baseline value. It means the tubing for CO2 is open to room air and no flow passing the flow-pressure sensor if there is one connected

Pressing the "SET" key will perform the baseline calibration. Pressing the "FN" key will keep the previous base-line calibration.
The system passes automatically to the next step:

If no Air TP/AF sensor is used, the calibration function automatically jumps to the CO2 calibration.

If the TP/AF sensor is present, the following steps are prompted:

As it is difficult to generate a constant flow for calibrating the air flow sensor, the ventilator mainly present is used for calibrating the volume and therefore the flow. The following lines appear on the screen:

In case of a rat guinea mouse sensor

Set Ventilator to SV = 200ul (Stroke volume)
RR = 200bpm
Press <Fn> for next parameter
Press <SET> to proceed

In case of a rat guinea rat guinea pig sensor

Set Ventilator to SV = 1.0 ml (Stroke volume)
RR = 100bpm
Press <Fn> for next parameter
Press <SET> to proceed

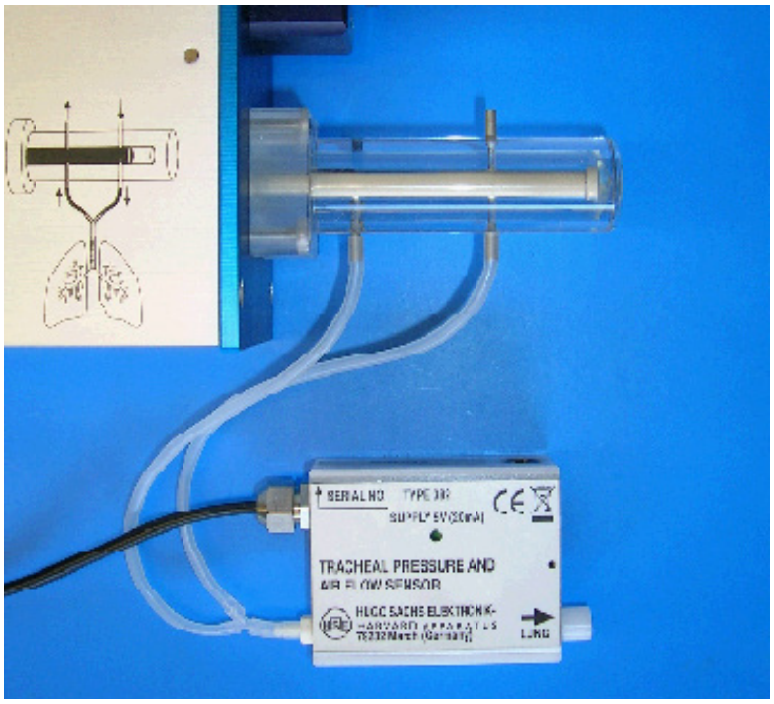
The ventilator should be set as requested and switched on.
If you pressed the <SET> key and the ventilator is not switched on, after a while you will get the following error message:

Switch Ventilator on !!!

If the ventilator is switched on you'll get the message:

Wait !!!
25 Pump cycles are required

The calibration process requires 25 ventilator cycles for the calibration



on the next version update you will have the following alternative choice

Set Airflow to 60 ml/min
Press <Fn> for next parameter
Press <SET> to proceed

To produce a constant flow trough the sensor, a rotameter or a syringe pump (PHD 2000 or PHD Ultra) can be used.
Tidal volume is automatically calibrated during this process.
Pressing the "SET" key will perform the calibration. Pressing the "FN" key will keep the previous calibration and skip to the

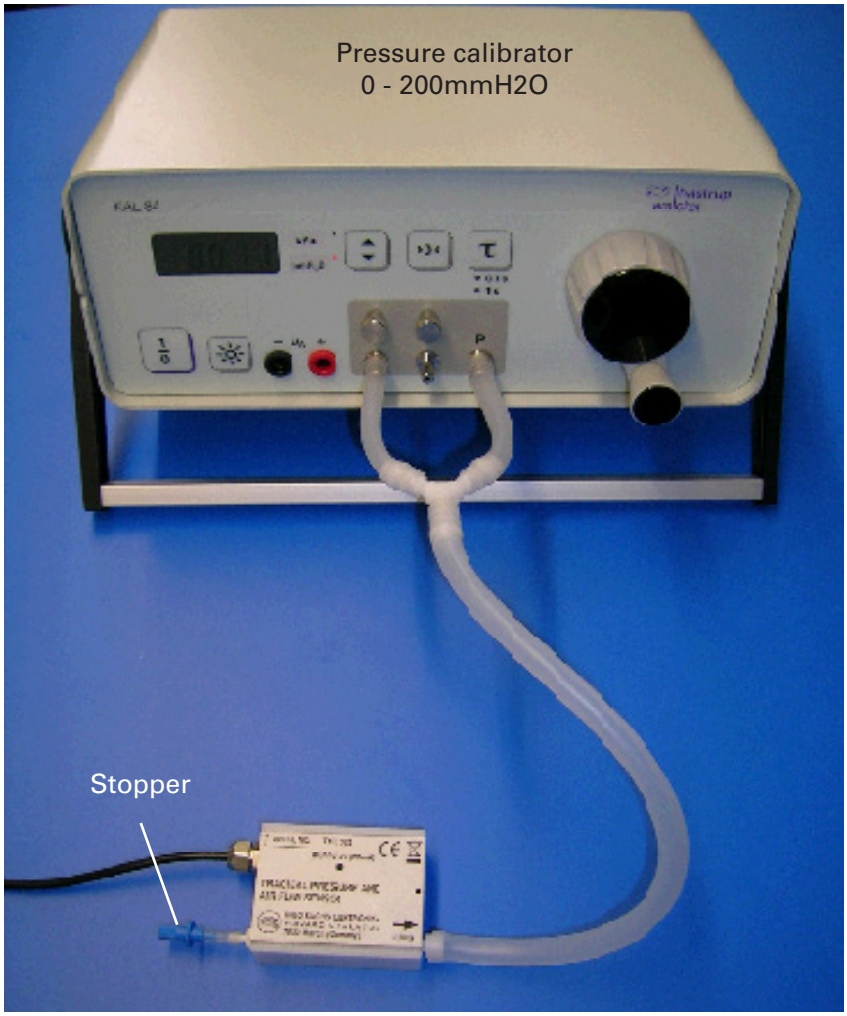
next parameter.

Set Tracheal Pressure to 10 cmH2O
Press <Fn> for next parameter
Press <SET> to proceed

Apply a pressure of 10 cmH2O (100mmH2O) to the port receiving the cannula holder, by maintaining the other port closed using the delivered stopper. Use a standard pressure calibrator.

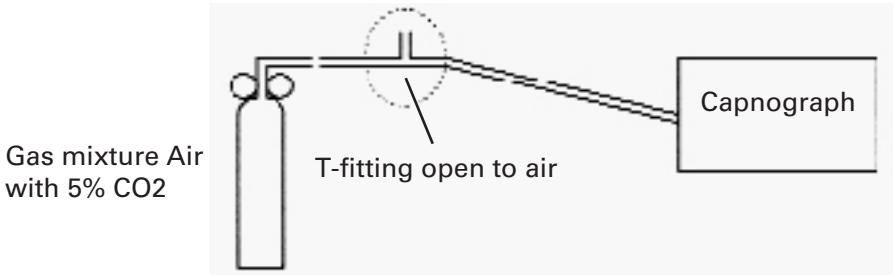
Pressing the “SET” key will perform the calibration. Pressing the “FN” key will keep the previous calibration.

After this last parameter, the system returns to the function menu and passes to the next menu item “Display”



Set CO2 to 5%
Press <Fn> for next parameter
Press <SET> to proceed

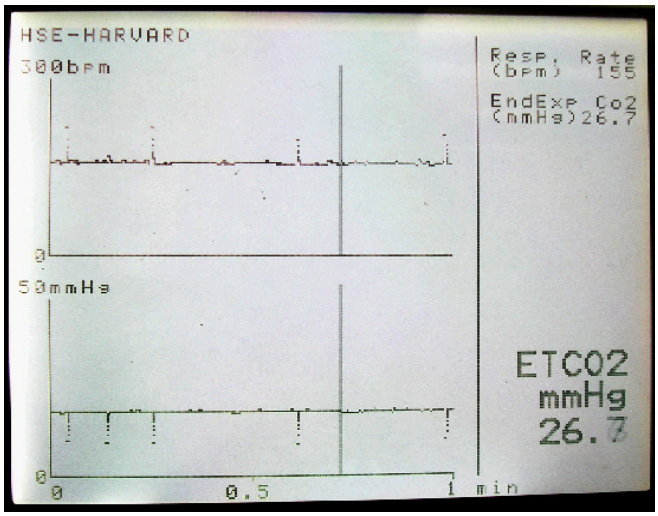
Supply the sensor by using a bypass with a gas mixture (room air + CO2) containing 5% CO2. It can be a tank with the finished gas mixture commonly available in laboratories, or a gas mixing system based on a supply of compressed air, a supply of CO2 and two rotameters. The gas must be regulated in such a way as to prevent over-pressurizing the sensor inside the capnograph.
The implementation in the picture below works well, provided that adequate flow is drawn by the capnograph and excess CO2 is observed blowing out of the T-fitting. The port of the T-fitting open to air can be equiped with a tubing immersed in a few millimeters of water to be sure enough but not too much gas is supplied.
Pressing the “SET” key will perform the baseline calibration. Pressing the “FN” key will keep the previous baseline calibration.



7.3.3 Function Display

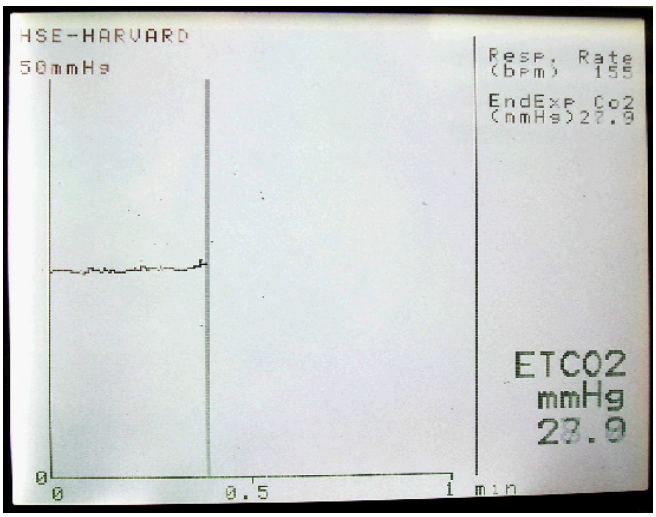
Depending on the configuration of the system (with or without the TP/AF sensor), this function will allow you to select different Display modes.

Without TP/AF sensor:



Numerical Display:
- Respiratory Rate
- Endexpiratory CO2

Graphical Display:
- Respiratory rate
- Endexpiratory CO2

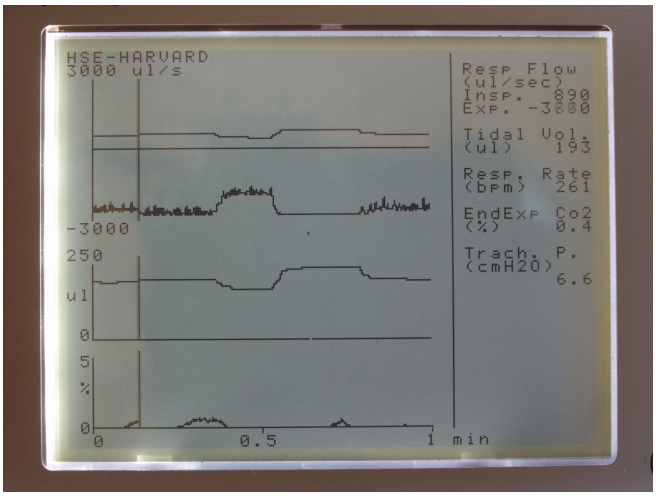


Numerical Display:
- Respiratory Rate
- Endexpiratory CO2

Graphical Display:
- Endexpiratory CO2

UP or **DOWN** key toggle between the screens one's the function entered

With Air flow Tracheal Pressure sensor:

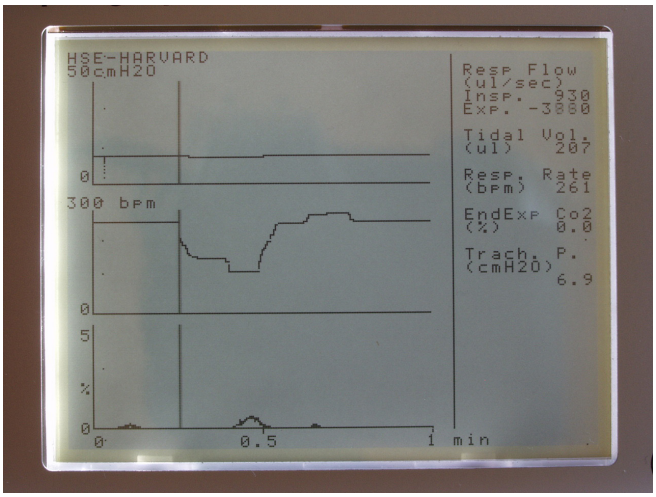


Numerical Display:

- Maximum Inspiratory Flow
- Maximum Expiratory Flow
- Tidal Volume
- Respiratory Rate
- Endexpiratory CO2 (ETCO2)
- Maximum Tracheal Pressure (Peak inspiratory pressure PIP)

Graphical Display:

- Tracheal Pressure (PIP and EEP)
- Tidal Volume (TV)
- Endexpiratory CO2 (ETCO2)

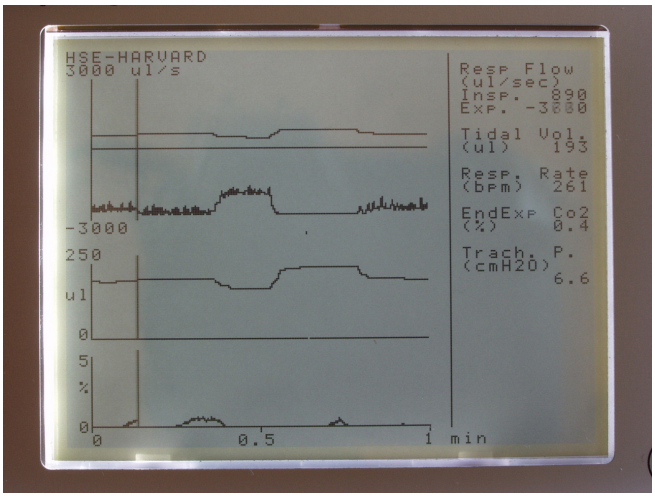


Numerical Display:

- Maximum Inspiratory Flow
- Maximum Expiratory Flow
- Tidal Volume
- Respiratory Rate
- Endexpiratory CO2 (EEP)
- Maximum Tracheal Pressure (Peak inspiratory pressure PIP)

Graphical Display:

- Tracheal Pressure (PIP and EEP)
- Respiratory Rate (RR)
- Endexpiratory CO2 (ETCO2)



Numerical Display:

- Maximum Inspiratory Flow
- Maximum Expiratory Flow
- Tidal Volume
- Respiratory Rate
- Endexpiratory CO2
- Maximum Tracheal Pressure

Graphical Display:

- Maximum Inspiratory Flow
- Maximum Expiratory Flow
- Tidal Volume
- Endexpiratory CO2

UP or **DOWN** key toggle between the screens one's the function entered

7.3.4 Function Flow Compensation

If no TP/AF sensor is connected, that function will not be displayed.

The function "flow compensation" allows to read the bypass flow rate to the CO2 sensor. This value is used to correct the flow and tidal volume accordingly.

After having entered the function with the "SET" key, the display will show:

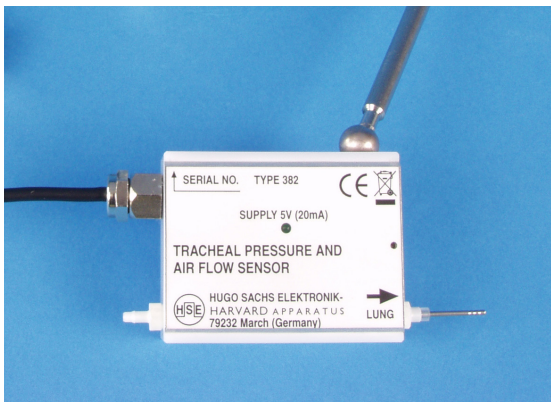
Read Compensation Flow
Press <Fn> for next parameter
Press <SET> to proceed

Pressing the "SET" key will start the reading procedure for the compensation flow. Pressing the "FN" key will exit the procedure and keep the previous reading.

After pressing the "SET" you'll be prompted to disconnect the cannula holder from the TP/AF sensor to read the baseline value without Bypass flow.

Press <SET> to measure Baseline
Disconnect cannula holder from Head

- Disconnect all from the TP/AF sensor (see figure on right)
- Wait a few seconds for stable conditions
- Press the "SET" key
- The measurement requires about 5 seconds, during that time you get the message



Wait !!!
Press <SET> to measure Baseline
Disconnect cannula holder from Head

After the Baseline is acquired you'll be prompted to connect the cannula holder to the TP/AF sensor to read the flow compensation value.

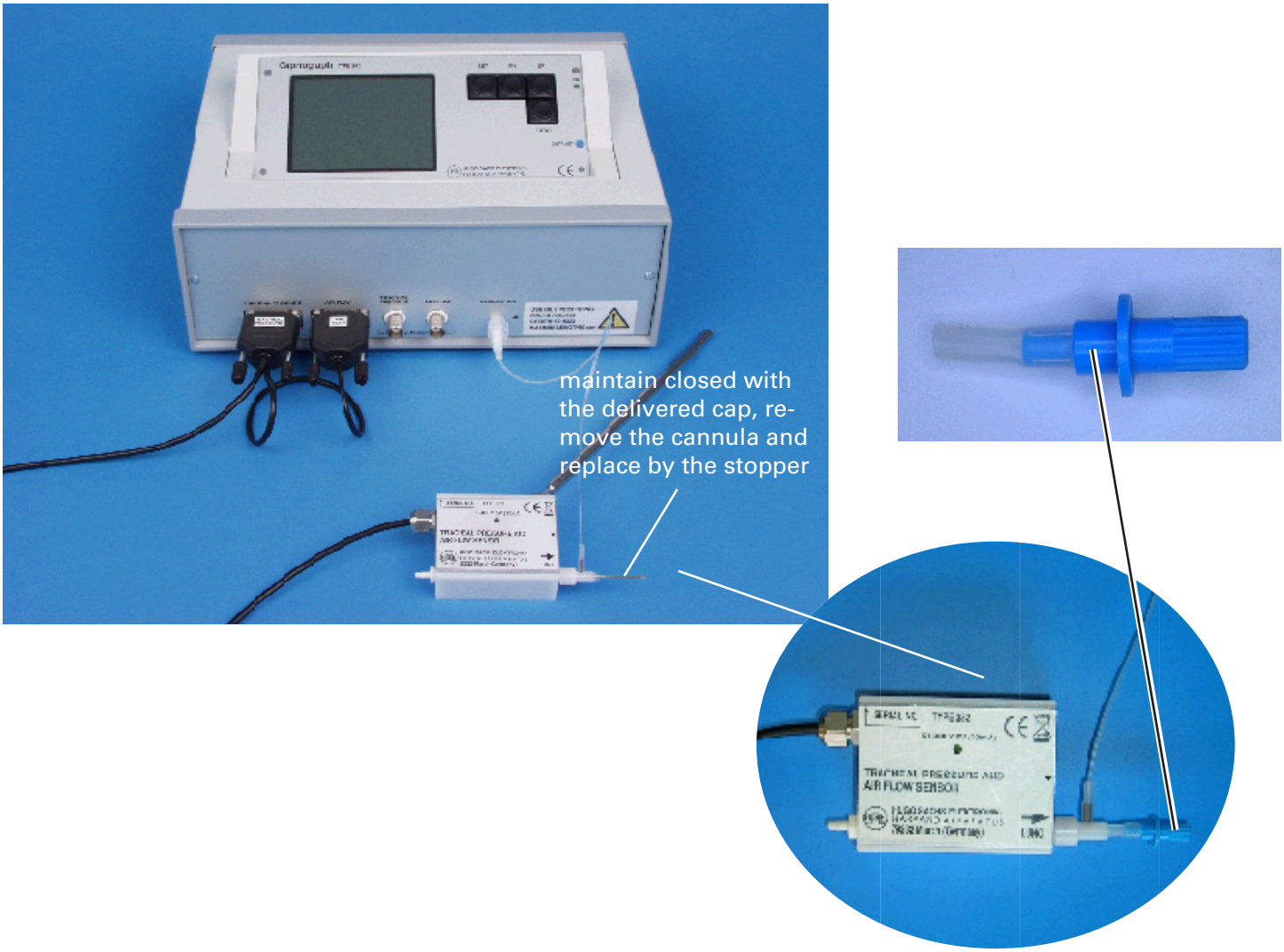
Press <SET> to measure Compensation
Connect cannula holder to Head

At that timepoint, after the first step you can exit the procedure by using the <FN> key, the flow compensation will stay unchanged.

Before you it the key "SET" to read the compensation you mut reconnect the cannula holder by having the cannula replaced by the special cap delivered with the unit. See figure below.

- Wait a few seconds for stable conditions
- Press the "SET" key
- The measurement requires about 5 seconds, during that time you get the message

The port connected to the ventilator or room air remains open, while the cannula port is maintained closed using the delivered stopper. (See below)



WAIT !!!
Press <SET> to measure Compensation
Connect cannula holder to Head

After a few seconds the compensation flow is show on the display

Pump Flow = 13 ml/min

Press <SET> to repeat the measurement

The value should range between 12 and 15 ml/min. If not repeat the procedure by pressing the key “SET”. Both steps measurement of baseline and of compensation are repeated.

If the key “FN” is pressed, the value is accepted and stored, the system returns to the function menu and passes to the next menu item “Output calibration”.

7.3.5 Function Output Calibration

The function output calibration allows to set at all recording outputs to a defined value for adapting a recording device, depending on the configuration of the system (with or without TP/AF sensor). The TP/AF sensor should not be connected to the ventilator nor to the animal. The calibration is in two steps, first the baseline and secondly the calibration values. After having entered the function with the "SET" key, the display will show:

All recording outputs at 0
Press <Fn> for next parameter
Press <SET> to proceed

by pressing set on all the recoding outputs the "0" value is issued.

The voltage at the BNC outputs is 0 Volt

Pressing the "SET" or the "FN" key will initiate the next step.

At the analog outputs a voltage is generated corresponding to the display values.

If the scaling of ETCO2 is set to "50mmHg" or "100mmHg"

In case of a mouse sensor

Flow = 1000ul/sec TV = 200ul
TP = 10 cmH2O RR = 200bpm
ETCO2 = 40mmHg CO2 = 40mmHg

Calibration value at outputs
Press <Fn> for next parameter
Press <SET> to proceed

In case of a rat guinea sensor

Flow = 1.0ml/sec TV = 2.0ml
TP = 10 cmH2O RR = 200bpm
ETCO2 = 40mmHg CO2 = 40mmHg

Calibration value at outputs
Press <Fn> for next parameter
Press <SET> to proceed

In case of no sensor

ETCO2 = 40mmHg CO2 = 40mmHg
RR = 200bpm

Calibration value at outputs
Press <Fn> for next parameter
Press <SET> to proceed

If the scaling of ETCO2 is set to "5%" or "10%"

In case of a mouse sensor

Flow = 1000ul/sec TV = 200ul
TP = 10 cmH2O RR = 200bpm
ETCO2 = 5% CO2 = 40mmHg

Calibration value at outputs
Press <Fn> for next parameter
Press <SET> to proceed

In case of a rat guinea sensor

Flow = 1.0ml/sec TV = 2.0ml
TP = 10 cmH2O RR = 200bpm
ETCO2 = 5% CO2 = 40mmHg

Calibration value at outputs
Press <Fn> for next parameter
Press <SET> to proceed

In case of no sensor

ETCO2 = 5% CO2 = 40mmHg
RR = 200bpm

Calibration value at outputs
Press <Fn> for next parameter
Press <SET> to proceed

Output voltages are as following:
2.0 Volt for the displayed value at the analog outputs TV, RR, ETCO2, CO2
1.0 Volt for 10cmH2O at the analog output for tracheal pressure
2.5 - 3 Volt for the displayed value at the analog output for the respiratory flow.

Pressing the "SET" or the "FN" key will initiate the next step.
After entering the settings, the system leaves the function menu and returns to the selected display and scaling window.

8. Cleaning the apparatus

Any traces of salt solution should be removed immediately with a cloth in order to avoid corrosion damage on the metal parts, the controls and the electronics.

For cleaning the front panel, controls and connecting cable never use scouring powder or cleaning agents which tend to dissolve plastics.

Any dust should be removed with a lint-free cloth or a fine dust brush.

Serious dirt can be removed with soapy water or a conventional mild domestic detergent, using a soft cloth. Then wipe off with clear water. Never allow any liquid to pass into the equipment or into the switches and sockets.

The window over the display is made of **PLEXIGLAS®** see at the end of the document the chemical Behavior of the material (§12)

Spots on the aluminium front panel can readily be removed using an ordinary plastic pencil rubber.

The interior of the equipment does not require any servicing or cleaning.

9. Maintenance and servicing

No special maintenance or servicing is requires.

We recommend:

- TP/AF sensor calibration ones a month
- CO2 Sensor calibration every 6 months

Of course in case of doubt on the results verify the calibrations.

If mucus has entered the FLow / Pressure head or the tubing connecting the cannula to the Capnograph, it may be necessary to do a recalibration of entire system.

In case of an obstruction in the Flow pathway inside the Flow / pressure head of the tubing connecting the cannula to the capnograph it is necessary to send the Head back to factory for entire cleaning and to exchange the tubing for a new one.

10. Faults, causes and remedies

 Display is Black or White after switching on

If the power switch is on and the green LED on the front panel lights up the unit should first show the initialisation and than the selected display setup

I*f not check:*

- is the "CONTRAST" adjustment turned full CCW (black display) ?

- is the "CONTRAST" adjustment turned full CW (white display) ?

 Error messages about the TP/AF Sensor

If the power switch is on and the green LED on the front panel lights up the unit should first show the initialisation and than the display shows Error messages concerning the TP/AF sensor connection

An*alyze the error message and check:*

- are both connectors pluged in ?

- are they pluged on the right input connector on the main unit ?

- are they pluged on the connectors secured ?

 No Flow Calibration possible

There is no flow through the flow sensor for calibration.

The *following should be checked:*

- is the lumen iside the sensor free, has no mucus entered the sensor (is case of the sensor must be returned for cleaning) ?

- is the connection to the ventilator correct ?

- is the port for connecting the cannula open ?

 No Flow flow compensation is measured

When the function "FLOW COMPENSATION" is selected no bypass flow is measured.

The *following should be checked:*

- is the port for connecting the cannula closed using the stopper ?

- is the ventilator disconnected ?

- is the lumen iside the sensor free, has no mucus entered the sensor (is case of the sensor must be returned for cleaning) ?

- is the tubing connecting to the head to the capnograph free, has no mucus entered the tubing (is case of the tubing must be replaced) ?

- is the internal pump working (connected a tubing on the back side of the main unit at the outlet port and immerse it into a beacker with water, observe the bubbles) ?

 *N*o CO2 Calibration possible

After calibration the sensor does not measure CO2

The f*ollowing should be checked:*

- is the capnograph connecting tubing free, has no mucus entered the tubing (in case of the tubing must be replaced), is it connected to the unit ?

- is the internal pump working (connected a tubing on the back side of the main unit at the outlet port and immerse it into a beacker with water, observe the bubbles) ?

- is the gas mixture as expected 95% air or nitrogen and 5%CO2 ?

- was any leackage on the gas mixture supplying line ?

 *N*o CO2 measurement or slow and low CO2 measurement

The fo*llowing should be checked:*

- is the capnograph connecting tubing free, has no mucus entered the tubing (is case of the tubing must be replaced), is it connected to the unit ?

- if a flow pressure head is used, is the flow pathway free, is the expiration phase ok or is the head or the ventilaor blocked ?

- is the calibration ok ?

- is the internal pump working (connected a tubing on the back side of the main unit at the outlet port and immerse it into a beacker with water, observe the bubbles) ?

 *Sca*ling is wrong

When the system is started and connected to the animal the scaling for the signals on the display is wrong. The reason may be that the system was used before without Flow pressure head and is now used the first time with the sensor

The fol*lowing should be done:*

- redo scaling of all parameters using the "SCALING" function

 ETCO2 shows always 0.00

The foll*owing should be checked:*

- is there a pulsatile signal at the CO2 input

To calculate properly the ETCO2, a pulsatile CO2 signal is required. Applying a constant CO2 value like during calibration does not give a reading of ETCO2.

The graphical display also does not show any ETCO2

 *TP/A*F Sensor is calibrated but without connected naimal and with ventilator running, The TV displayed is less than set on the ventilator:

- This *is not a default of the instrument.*

The calculation of the TV already substracts the sample volume of the Bypass for CO2 measurement. It calculates the real TV entering the animal. The TV shown is about 30 µl less than the value set at the ventilator for a RR of 100bpm

11. Technical characteristics of the TP/AF sensor

	Mouse	Rat
Range: - Flow sensor: - Tracheal pressure sensor:	 +/- 10,5 ml/sec 0 – 76,5 cmH2O	 +/- 27 ml/sec 0 – 76,5 cmH2O
Sensitivity: - Flow sensor: - Tracheal pressure sensor:	 ~ 22 µV/V/ml/sec ~ 20 - 23 µV/V/cmH2O	 ~ 8,5 µV/V/ml/sec ~ 20 - 23 µV/V/cmH2O
Housing Size L/W/H Weight Dead Space	80 x 45 x 22 mm 140 g (65) 225 µl*	80 x 45 x 22 mm 140 g (134) 330 µl*

* Value in brackets = Sensor head, other value sensor head with tracheal cannula connector

12. Chemical Behavior of PLEXIGLAS®

The symbols signify:
+ resistant
- not resistant
o limited resistance

The data given below refer to a test temperature of 23° C and assume stressfree installation. The behavior of the material in practice depends largely on the temperature in use. In case of doubt, we advise you to consult us as to the chemical resistance for particular applications. The results obtained for all products, especially the branded ones, refer to the production batch tested in each case.

Antistatics :

+ HB 155
+ Antistatic fluid and cleaning agent

Technical baths :

+ Electroplating baths
+ Photochemical baths

Chemicals, solvents, etc.
a) General

- Acetic acid, concentrated
+ Acetic acid, up to 25 %
- Acetone
+ Alum
+ Aluminium chloride
+ Aluminium oxalate
+ Aluminium sulphate
- Ammonia water
+ Ammonium sulphate
- Amyl acetate
- Aniline
+ Arsenic
+ Arsenic acid

+ Battery acid
- Benzaldehyde
+ Benzine, pure
- Bromine
- 1-Butanol
- Butyl lactate
- Butyric acid, up to 5 %
+ Calcium chloride
+ Calcium hypochlorite
- Carbon disulfide
- Carbon tetrachloride
- Chlorinated hydrocarbons
- Chlorine, liquid
o Chlorine water
- Chloroethyl ether
- Chlorophenol
o Chromic acid
+ Citric acid, up to 20 %
+ Copper sulphate
- Cresol
+ Cyclohexane

- Diacetone alcohol
o Diamyl phthalate
-- Dibutyl phthalate

+ Diethylene glycol
- Dioxane
- Ether
- Ethyl acetate
- Ethanol, concentrated
o Ethanol, up to 30 %
- Ethyl bromide
- Ethyl butyrate
- Ethylene bromide

+ Ferric chloride
+ Ferrous chloride
+ Ferrous sulphate
+ Formic acid, up to 2 %
o Formic acid, up to 40 %

+ Glycerol
+ Glycol
+ Heptane
+ Hexane
+ Hydrochloric acid
+ Hydrofluoric acid, up to 20 %
+ Hydrogen peroxide, up to 30 %
+ Iodine, metallic
+ Lactic acid, up to 20 %
+ Magnesium chloride
+ Magnesium sulphate
+ Manganese sulphate
+ Mercury
- Methanol, concentrated
o Methanol, up to 30 %
- Methyl ethyl ketone
- Methylated spirits
+ Milk of lime
+ Monobromonaphthalene

+ Nickel sulphate
+ Nitric acid, up to 40 %
+ Nitric acid, over 40 %

+ Oxalic acid

- Perchloroethylene
+ Petroleum
+ Petroleum ether
- Phenols
+ Phosphoric acid, up to 50 %
- Phosphorus trichloride
- Phosphorus, white
+ Picric acid, 1 % in water
+ Potassium bichromate
+ Potassium carbonate
+ Potassium chloride
+ Potassium cyanide
+ Potassium hydroxide solution
+ Potassium nitrate
+ Potassium permanganate
o 2-Propanol
+ Propylene
- Pyridine
- Silicon tetrachloride
+ Silver nitrate
+ Sodium bisulfite
+ Sodium carbonate
+ Sodium chlorate
+ Sodium chloride
+ Sodium hydroxide solution, 30 %
+ Sodium hypochlorite
+ Sodium sulphate
+ Sodium sulphide
+ Stannous chloride
+ Stearic acid
+ Sulphur -Sulphur dioxide, liquid
+ Sulfuric acid, up to 30 %
o Sulphurous acid, conc.
+ Sulphurous acid, up to 5 %
+ Sulfuryl chloride
+ Tartaric acid, up to 50 %
- Thionyl chloride
- Toluene
+ Triethylamine
- Trichloroacetic acid
+ Turpentine
+ Turpentine substitute

+ Urea, up to 20 %

- Xylene

+ Zinc sulphate, aqueous
+ Zinc sulphate, solid

b) Branded products:

+ CLOPHEN® T 55, A60
o DEKALIN®
o FRIGEN® A 12(CF CL)
- GLYBAL® A
2 2

+ PALATINOL® K
o PALATINOL® O, BB new
+ SANGAJOL®
+ TERAPIN®
- TETRALIN®

Disinfectants
a) General

- Carbolic acid
+ Chlor. lime paste
- Hydrogen peroxide, up to 40 %
o Hydrogen peroxide, over 40 %
- Iodine tincture, 5 %
+ Lugol solution
- Methylated spirits
+ Sublimate

b) Branded products

o ÄTHROL®, up to 5 %
+ BAKTOLAN®, up to 5 %
- BAKTOLAN®, conc.
+ CHINOSOL®, up to 1 %
- CHLORAMIN®, suspension
+ CHLORAMIN®; solution
+ ELMOCID GAMMA®, up to 2% - LYSO-FORM®
+ MEFAROL®, up to 1 %
+ MERCKOJOD®, up to 1 %
+ MERFEN®
+ PERHYDROL®
+ PERODIN®
+ SAGROTAN®, up to 2 %
o SAGROTAN, up to 5 %
o VALVANOL, up to 2 %
+ ® ZEPHIROL; up to 5 %

Fats, oils, waxes :

+ Animal
+ Mineral
o Silicone oil
+ Vegetable

Gases and vapours

+ Ammonia
o Bromine vapours, dry
+ Carbon dioxide
+ Carbon monoxide
+ City gas
o Chlorine vapours, dry
+ Exhaust gases containing HCl
+ Exhaust gases containing HF
+ Exhaust gases containing H_2SO_4
+ Hydrogen sulphide
+ Methane
+ Nitrogen dioxide
+ Nitrogen monoxide
+ Oxygen
+ Ozone
+ Sulphur dioxide, dry

Beverages, etc.

+ Beer, Wine
+ Camomile extract
+ Chocolate
+ Fruit juice, milk, coffee
o Spirits, up to 30 %
+ Vinegar
+ Water, mineral water

Cosmetics, etc.

- Camphor
+ DIPLONA® -hair oil
+ Face tonic
+ Glycerine
+ Hair setting lotion (PRIMAWELL)
- Nail varnishes
- Nail varnish removers
+ Ointments
+ Peat water
+ POLYCOLOR®
+ Seawater
+ Soaps
o Sprays

Plastics

+ Foam plastics
- Foam plastics, plasticised
+ Polyamide
+ Polyethylene
+ PVC
- PVC, plasticised
- Rubber
- Rubber, plasticised

Foods and spices

+ Aniseed, bay leaf, nutmeg -Cloves
+ Common salt
+ Honey, pure
+ Ice cream
+ Meat, fish
+ Pepper, cinnamon, onions
+ Pickles

Cleaning agent
a) General

Acids, see under chemicals
- Alcohol, concentrated
o Alcohol, up to 30 %
Alkalis, see under chemicals
+ Ammonia solution
- Benzine, mixture, containing aromatics
+ Benzine, non-aromatic
+ Bleach
- Carbon tetrachloride
- Methylated spirits
- Perchloroethylene
+ Petroleum
+ Petroleum ether
+ Soap solution
+ Soda water
- Stain remover
- Trichloroethylene
+ Turpentine
+ Turpentine substitute

b) Branded products

+ AJAX®
+ Antistastischer KUNSTSTOFF® REINIGER und Pfleger
+ BFK® cleanser
+ BOLIMENT®
+ BÖTTCHERIN®
+ BURMAT®
+ BURNUS®
+ CILLIT-GRÜN®
+ DOR®
+ DOSYL®
+ DOSYLAN®
+ FAKO®-Polish
+ FAKO®-Polishing paste
+ FEWA®
+ FRAPPIN®
+ FÜLLBOX®
+ LAWAPLEX®
+ NULL-NULL®
+ PERSIL®
+ PLEXIKLAR®
+ PRIL®
+ REI®
+ SEIFIX®
- SIDOLIN®
- SPECTROL®
+ SPÜLI®
+ WC-00®

c) Cleaning agents for pipes and tanks

+ CALGONIT® D, DA, S
+ NEOMOSCAN® M, M powder
+ NIROKLAR® GR liquid
+ NIROKLAR® GR powder
+ P 3®
o P 3 basic cleaner
+ P 3- dix

Pesticides

- Sprays (applied directly)
o Sprays (applied in the air)
o Pesticides in aqueous solutions
+ NEXION® stable spray
+ RABOND® stable spray

Protective coatings (strippable)

+ DIEGEL® liquid film 23922
+ KOPPERSCHMIDT® covering paste
o SPRAYLAT®

Other substances

+ Urine
- Fuel for petrol engines
o Fuel for diesel engines

13. Reply Form

Please take a few minutes of your time in order to write to us regarding any difficulties in understanding the Operating
Instructions or in the use of the apparatus. Your feedback will help us to improve our products and the system documentation and make them more user-friendly.

Please tell us:

- where you have found mistakes,
- where the arrangement was not clear and what you did not understand,
- and where you would like to see improvements.

Many thanks for your *kind assistance.*
Yours HUGO SACHS ELEKTRONIK -
HARVARD APPARATUS GmbH.

Your name _____
Organization _____
Street _____
Town _____
Phone / Fax _____
Email _____

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Please send this sheet or a copy to:
HUGO SACHS ELEKTRONIK -
HARVARD APPARATUS GmbH
Gruenstr. 1, D-79232 March-Hugstetten, Germany
Fax (int. +49) 7665/9200-90