Instruction Manual

CALIBRATION UNIT

AFCU-360M

symbol image

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All necessary notes for a safe and proper handling with calibration units of type AFCU-360M are included in this manual. Read and respect this manual to avoid mistakes and danger.

Use of the instruction manual

Calibration units of type AFCU-360M are available in a wide range of different assemblies. Also a later upgrade with additional modules is possible. Therefore this manual includes maybe information which are not applicable for the present device or have to be applied in general sense. Chapters, where this is valid, include direct after the chapter heading the following indication.

Indication! Apply the information in this chapter in general sense according the assembly of the present device.

Symbol explanation

There are used symbols in this manual which refer to danger or important references. Therefore the meaning of the symbols should be memorised.

Danger! This symbol refer to danger, ordinance and prohibition to avoid personal or material damage.

Warning against electric energy! Note that work must only be carried out by trained electricians which know the danger of electric current.

Indication! Attention is brought to advice on the handling and economic use of equipment.

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Test Report, Gas flow chart, Wiring plan

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1. Introduction and operating principle

1.1. Intended use

The span gas generator unit AFCU-360M is developed for the daily function control of immission analyzers in ambient air monitoring station. It is not suitable to use the unit to calibrate the analyzers. For calibration special transferstandards have to be used.

1.2. Description of functions

The daily function control of immission analyzers has to be performed for Zero and for one concentration inside the measuring range (=span point). So we need three different states for the calibration unit.

- *Purge* Stand by operation of the calibration unit
  Analyzers are in measure operation. There is no gas from the calibration unit necessary.

- *Zero* Zero air is available at the calibration gas outlet.
  The zero point check of the analyzers can be performed.
  The zerogas, produced in a central zero gas generator, is fed to the calibration unit on the corresponding gas inlet.

- *Span* Spangas is available at the calibration gas outlet.
  The span point check of the analyzers can be performed.
  There are several ways to produce spangas. These possibilities are available:
  - Permeation
  - Dilution of gas from a cylinder
  - Gas-phase-titration (GPT)
  - UV radiation

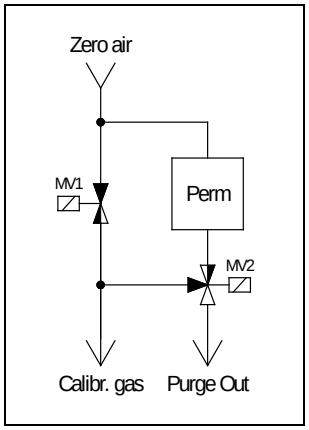
The listed possibilities of span gas production can exist multiple or in combination together in the present device, depending on the assembly. So we speak about several span gas channels or a multi-component calibration unit.
Refer to the flow schematic and the technical data in appendix A to get information about the present assembly.

The calibration unit use zero air produced by an external zero gas generator. If this zero air is not free of CO, a built in scrubber reduce the CO to offer dilution gas for the CO module. To adjust the individual flow rates thermal mass flow controllers are used. The reference setting for the thermal mass flow controllers is solved with potentiometers.

Indication! It is not allowed to perform the function control for several channels at the same time. In case of parallel operation of channels, the LED's indicate the selected states, however the AFCU-360M switches over to purge in automatic. This is no malfunction of the device..

1.2.1. Permeation

A permeation tube filled with fluid gas is placed in a block heated to a temperature of 50°C (permeation oven). At this high temperature gasiform gas is diffused through a membrane out of the tube. Provided the temperature remains constant, the amount of gas diffused out of the tube also remains constant. The released gas is mixed with zero air flowing past the tube. The calibration gas concentration level is obtained from the permeation rate of the tubes used and the adjusted flow rate of zero air.



Purge: A minimum flow (purging air) through the permeation ovens is maintained to prevent an increase in harmful substances in the chamber where the permeation tube is placed. The purging air is removed through a valve (MV2) and the purge outlet at the rear of the device. Valve MV1 is closed.

Zero: Valve MV1 is open. Zero air is available at the calibration gas outlet. The permeation oven is purged continuously.

Span: Valve MV1 is open and valve MV2 is activated. The gas trough the oven carries the gas from the permeation tube and is mixed with the zero air passing MV1. This calibration gas is available at the calibration gas outlet.

Calculation of the concentration

$$\text{Concentration}\left[\text{ppb}\right] = \frac{\text{Permeation rate}\left[\text{ng/min}\right]}{\text{Flow}\left[\text{l/min}\right]} \text{ x Factor}$$

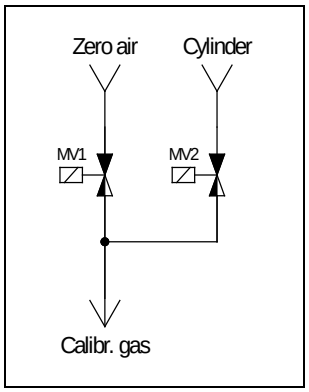
Permeation rate ..... according the certification of the tube, ascertain value respectively in case of an uncertified tube

Factor..... conversion factor between mass per units volume and the volume ratio (depends on the temperature the flow rates are referred to, ref. to technical data in appendix A)
Factor = 1: Concentration unit µg/m³
Factor ≠ 1: Concentration unit ppb

Flow ..... zero flow rate and flow from the permeation chamber. Refer to appendix A for the actual flow rates.

1.2.2. Dilution without cylinder purge flow

Gas from a gas cylinder is diluted with zero air to a concentration suitable for range calibration of immission analyzers. A continuous flow from the cylinder is not necessary. The cylinder flow rate at Span is high enough, or the used gas is very stable, to reach a stable calibration gas concentration with short rise time. The calibration gas concentration level is obtained from the concentration of the gas cylinder used and the adjusted dilution ratio.



Purge: Both valves are closed. No flow.

Zero: Valve MV1 is open. Zero air is available at the calibration gas outlet.

The cylinder gas MFC is starting an auto zero calibration procedure. This procedure takes approx. 7 minutes.

Span: Both valves are open. Cylinder gas is lead to the zero air. This calibration gas is available at the calibration *gas* outlet.

Calculation of the concentration

$$\text{Concentration}\,[\text{ppm}] = \frac{\text{Cylinder concentration}\,[\text{ppm}] \times \text{Cylinder flow rate}\,[\text{l/min}]}{\text{Total flow rate}\,[\text{l/min}]}\ \text{x}\ \frac{1}{\text{Factor}}$$

Cylinder concentration.....According to cylinder certificate

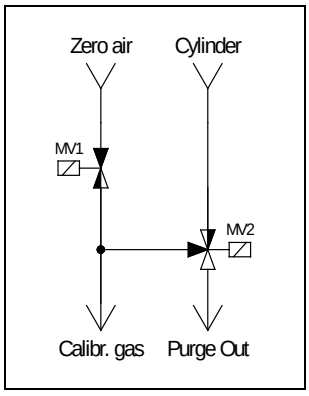
Cylinder flow rate.....cylinder gas flow rate (ref. to technical data in appendix A)

Total flow rate.....Total of dilution air and cylinder flow rate. Refer to appendix A for the actual flow rates.

Factor .....conversion factor between mass per units volume and the volume ratio (depends on the temperature the flow rates are referred to, ref. to technical data in appendix A)
Factor = 1: Concentration in unit ppm
Factor ≠ 1: Concentration in unit mg/m³

1.2.3. Dilution with cylinder purge flow

Gas from a gas cylinder is diluted with zero air to a concentration suitable for range calibration of immission analyzers. A continuous flow from the cylinder is necessary. The cylinder flow rate at Span is very small, or the used gas is very instable. This would cause a long rise time to reach a stable calibration gas concentration. The calibration gas concentration level is obtained from the concentration of the gas cylinder used and the adjusted dilution ratio.



Purge: A minimum flow from the cylinder is maintained. The purging air is removed through the purge outlet connector. Valve MV1 is closed.

Zero: Valve MV1 is open. Zero air is available at the calibration gas outlet. The cylinder gas MFC is starting an auto zero calibration procedure. Therefore there is no flow from the gas cylinder.

Span : Valve MV1 is open and valve MV2 is activated. Cylinder gas is lead to the zero air. This calibration gas is available at the calibration gas outlet.

Calculation of the concentration

For the calculation use the same formula as described in item 1.2.2.

1.2.4. Dilution of mix gas cylinder

A gas cylinder for dilution can be filled with more than one gas component. Hence several analyzers are supplied from only one channel. This dilution can be without (chapter 1.2.2) or with (chapter 1.2.3) cylinder purge flow.

The functionality in state Purge, Zero and Span is the same as described in the chapter for the used type of dilution module.

Calculation of the concentration

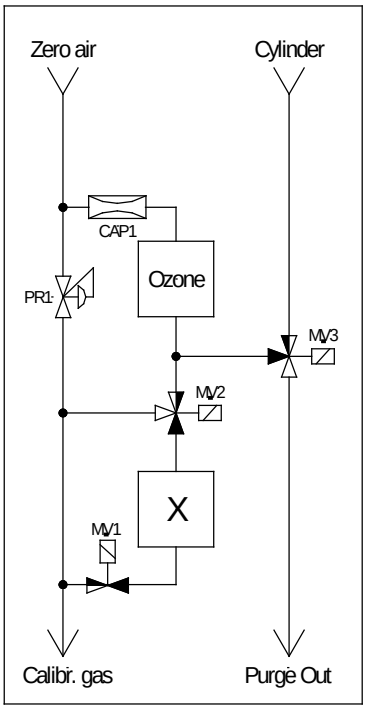
For the calculation use the same formula as described in item 1.2.2.

Indication! Take care of the amount of zero air according appendix A. The sum of the analyzer flow rates, which use gas from this channel at the same time, must be lower than the offered zero gas flow rate. Therefore it can be necessary to perform the function control of the connected analyzers in serial and not simultaneously.

1.2.5. Gas phase titration

A dilution channel for NO can be extended with a gas phase titration (GPT) module. Hereby NO is converted to NO_2 by using ozone.

The ozone is obtained by exposing zero air to UV light. The HG lamp required for this purpose is placed in an oven heated to a temperature of 70°C (O_3 oven). The zero air passes through a glass tube past the source of UV, where a portion of oxygen is oxidised into O_3. In an addition mixing chamber the reaction of NO with O_3 for producing NO_2 is done. Two different NO/NO_2 ratios are possible because of different lamp intensities between GPT1 and GPT2.



Purge: A minimum flow from the cylinder is maintained. The purging air is removed through the purge outlet connector. Valve MV1, 2 and 3 are closed or not activated.

Zero: Valve MV1, MV2, MV3 are not activated. Zero air is available at the calibration gas outlet. The cylinder gas MFC is starting an auto zero calibration procedure. Therefore there is no flow from the gas cylinder.

Span NO: Valve MV1, MV2, MV3 are activated. The lamp is off. Cylinder gas is lead to a small amount of zero air. This amount of Zero air is independent from the total Zero air always the same. Together they pass a reaction chamber, and finally they are mixed with the rest of zero air. This calibration gas is available at the calibration gas outlet.

Span GPT: Same functionality than Span NO, but the lamp is switched on for the production of ozone. Ozone and NO passes the reaction chamber. The result is a NO/NO_2 mixgas. The NO_2 concentration depends on the level of ozone. Finally this gas is lead to the rest of zero air and the calibration gas is available at the calibration gas outlet.

Calculation of the converter efficiency

To determine the converter efficiency it is not necessary to know the NO/NO2 ratio of the produced NOx gas, respectively the O_3 concentration.

Formula to calculate the converter efficiency:

$$E_{conv}[\%] = \left(1 - \frac{(\mathrm{NOx})_i - (\mathrm{NOx})_f}{(\mathrm{NO})_i - (\mathrm{NO})_f}\right) x\,100$$

where

E_{conv}.....converter efficiency in %

$(NOx)_i$ ..... average of the measurement at the NOx channel at the initial NOx concentration without O_3

$(NOx)_f$ ..... average of the measurement at the NOx channel at the resulting NOx concentration after applying O_3

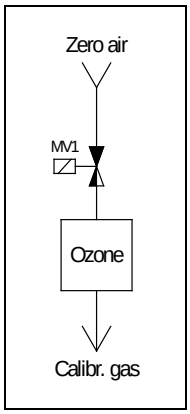
$(NO)_i$ ..... average of the measurement at the NO channel at the initial NOx concentration without O_3

$(NO)_f$ ..... average of the measurement at the NO channel at the resulting NOx concentration after applying O_3

For more detail how to perform the converter efficiency check refer to European Standard No. EN 14211.

1.2.6. UV Radiation

Ozone calibration gas is obtained by exposing zero air to UV light. The HG lamp required for this purpose is placed in an oven heated to a temperature of 70°C (O_3 oven). The zero air passes through a glass tube past the source of UV, where a portion of oxygen is oxidised into O_3. The degree of concentration of the calibration gas is a result of the lamp intensity and the flow rate.



Purge: The valve is closed. No flow. The lamp is off.

Zero: Valve MV1 is open. Zero air is available at the *calibration* gas outlet. The lamp remain off.

Span: Valve MV1 is open and the lamp is on. Calibration gas is available at the calibration gas outlet.

Calculation of the concentration

$$\text{Concentration}\left[\text{ppb}\right] = \frac{\text{Concentration at 1l/min}\left[\text{ppb}\right]}{\text{Flow rate}\left[\text{l/min}\right]} x \frac{1}{\text{Factor}}$$

Concentration at 1 l/min .....ascertain value. To ascertain this value, the calibration unit must be measured using a correctly set analyzer.

Flow .....amount of zero air through the mass flow controller

Factor .....conversion factor between mass per units volume and the volume ratio (depends on the temperature the flow rates are referred to, ref. to technical data in appendix A)
Factor = 1: Concentration in unit ppb
Factor ≠ 1: Concentration in unit µg/m³

2. Transport, storage, installation, start-up procedure

2.1. Transport and storage

Indication! Apply the information in this chapter in general sense according the assembly of the present device.

On transportation and storage the turned off device the permeation tube have to be removed from the permeation oven. The device, and special the electric equipment in the device has to be protected against humidity.
Should the calibration unit be stored long term or not used for a long period of time, it should be protected from getting dirty. Otherwise malfunction can occur in addition caused by dirt e.g. in the thermal mass flow controllers.

2.2. Environmental conditions

The calibration unit has to be used only in well ventilated area. The mounting place should not have hard vibrations. The room temperature should be between 5 and 35°C. Otherwise the room must be climatiziesed.

Danger! Strictly avoid temperature differences between the system and the environment which can cause condensation inside of the device.

2.3. Installation

Indication! Apply the information in this chapter in general sense according the assembly of the present device.

After locate the device on its place the gas- and electrical connections are done according the description below. Take care to avoid angle of the cables and tubes.

Danger! The exhaust gas at the Purge Outlet and Bypass connections have to be carried off to open air by use of tubes.

Danger! Basically the gas for the analyzers must be offered them depressurized. Be sure to install an external Bypass if the calibration unit has no internal Bypass connector (refer to flow schematic in appendix A). The external one can be inside the analyzer or installed as an external T-fitting in the tube between calibration unit and analyzer.

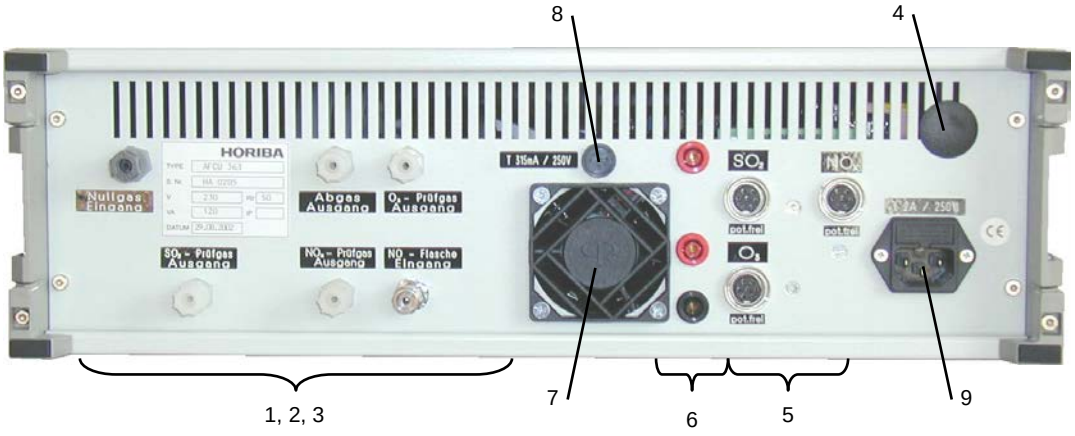


Fig. 1: Rear (symbol image)

1..... Gas Inlets	Fitting to connect the zero gas generator and the gas cylinders according labels on the rear panel. Refer also to the labels or the technical data in appendix A for the used inlet pressure.
2..... Calibration Gas Outlets	Fitting to connect the analyzers according labels on the rear panel.

3.....Purge Outlet	Fitting to discharge the purge flow.
4.....Bypass	Fitting to connect a tube to discharge the overflow of zero and span gases.
5.....Remote control	Sockets for connection to the analyzers according labels. Pinning see item 3.2.
6.....Test socket temperature	Option: Sockets to check the oven temperatures according label on the rear panel. (0-10V ^= 0-100°C)
7.....Fan	To discharge the heat from device inside.
8.....Fuse for fan	5x20mm fuse from type of 315mA / 250V for the fan.
9.....Power connector	Socket with integrated filter to connect the power supply of 230V / 50Hz. The socket includes also the main fuse for the device and 1 fuse as a spare part. Refer to label on the device rear panel or the wiring diagram in appendix A for the fuse capacity.

2.4. Start-up procedure

Indication! Apply the information in this chapter in general sense according the assembly of the present device.

1. Mount the permeation tubes. Refer to item 4.3 and 4.3.

   Indication! After mounting the permeation tube, the device should operate in purging state for approx. 24 hours to get a constant span gas values from the permeation systems.

2. Turn on the zero gas generator and adjust the pressure according labels on the rear panel or the technical data in appendix A.

3. Turn on the gas cylinder and adjust the pressure according labels on the rear panel or the technical data in appendix A.

   Indication! If a new gas cylinder is used or after the gas cylinder has been changed to a new one, the setpoint values of the calibration gas concentration has to be determined as described in item 2.4.1. Before doing this, the device should work at least 7 days to get a stable calibration gas.

4. Turn on the calibration unit with the power switch.

2.4.1. Determine the calibration gas concentration

We recommend the following procedure to determine the actual calibration gas concentrations.

1. Calibration of the analyzers with calibration gas sources where the concentration is known (e. g. Reference- or Transferstandard calibration unit)
2. Measurement of the actual span gas concentrations generated by the AFCU-360M on the well calibrated analyzers.
3. Use these values as setpoint values for future function controls.

For the theoretical calculation of the concentrations refer to chapter 1.2.1 to 1.2.6.

3. Equipment operation

3.1. Manual operation

Indication! Apply the information in this chapter in general sense according the assembly of the present device.

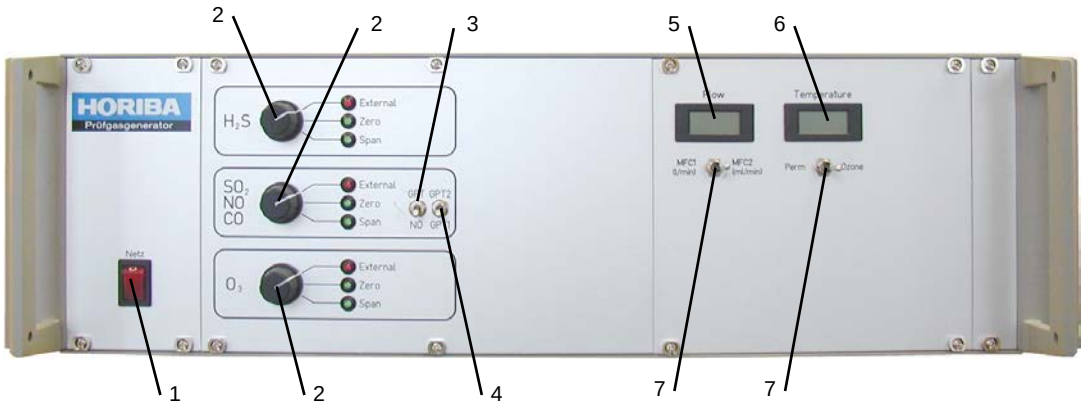


Fig. 2: Front (symbol image)

1..... Power switch	Switch to turn the device on and off.
2..... State switches	Rotary switch for manual change-over of the operating state. Selected state is indicated by LED´s.
3..... Switches for UV-lamp	Switch to turn the UV-lamp off (position NO) and on (position GPT). NO_2 is produced at GPT to check the NO_2/NO converter in the analyzer. The switch is active only in state Span.
4..... Lamp intensity switch	Switch to change between 2 different intensities of the UV-lamp. This switch is active only in state Span GPT.
5..... LC-display	To indicate the flow for MFC1 and MFC2.
6..... LC-display	To indicate the temperature of the oven.
7..... MFC/Temp. switch	Switch to select the LC-display indication for the flow rates of the MFC's and the temperatures of the ovens.

The rotary switch on the equipment front serves to change over into the individual operating states.

3.2. Remote control

The command to change over into the zero or span operating state can also be given by the respective analyzer. For this purpose the calibration unit must be in external mode. The change-over is activated by an isolated contact or a voltage of 24V DC applied on the respective pin, depending on the device configuration. Refer to the label on the rear panel or the technical data in appendix A for the actual configuration. The wiring of the sockets for the remote control is shown in Fig. 3.

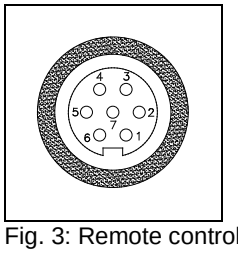


Fig. 3: Remote control socket

pin	function
1	Option: Alarm Manual
2	Option: Alarm Manual
3	Zero
4	Span
7	Common

4. Maintenance

Indication! Apply the information in this chapter in general sense according the assembly of the present device.

4.1. Maintenance interval

The table below shows the parts which have to be serviced and the belonging interval.

part	criteria	action	interval	item
CO Scrubber (SCR1)	Filling consumed	replace	3 years	4.3
Permeation oven (OVx)	span gas concentration is falling	exchange permeation tube	depends on the type of the tube	4.4
Permeation oven for BTX (OVx)	span gas concentration is falling	exchange permeation tube	depends on the type of the tube	4.5

4.2. Open the case

Warning against electric energy! Disconnect the device from the mains supply before open the case to execute maintenance works.

Procedure

1. Turn off the calibration unit. Disconnect main plug.
2. Loose two screws on the rear of the cover.
3. Pull the cover back softly and lift it.
4. Disconnect the ground cable from the cover and remove the cover.

4.3. Replace filling of the CO Scrubber

Procedure

1. Make sure that the scrubber is not pressurized by e.g. the zero air supply.
2. Open the case. Refer to item 4.2.
3. Loose the inlet and outlet fitting of the cartridge.
4. Remove the cartridge from the mounting clip.
5. Hold cartridge vertical. Release cap on the side of the spring by turning it counter clockwise and open the cartridge.
6. Remove spring, sieve and filter and drain the cartridge.
7. Refill the cartridge as far as the spring is compressed approximately to it’s half length at the closed cartridge (approx. 60ml).
8. Clean the packing in the cap.
9. Insert filter, sieve and spring and close the cap.
10. Fix the cartridge in the mounting clip.
11. Connect the inlet and outlet fitting.

4.4. Exchange permeation tube

The useful life time of the tube depends on the type of the tube and the permeation rate.

Danger! When exchange the tube harmful gases will be released. This work have to be done only in well ventilated area.

Danger! Hazard of burn of the skin.
In operation the oven is heated up to 50°C. For protection against burn of skin use suitable tolls or protective gloves.

Procedure

1. Open the case. Refer to item 4.2.
2. Loose screws on the top of the permeation oven. Lift the cap.
3. Remove the tube with suitable tools. Storage the tube at a well ventilated area to cool down.
4. Take a new tube out of the package.

   Danger! Take care for the notice on the package.
5. If necessary, remove the shrink tube from the neck of the permeation tube and write down the parameters from the shrink tube directly on the permeation tube by using a permanent maker.
6. Fit the permeation tube into the oven.
7. Grease the O-ring in the cap with silicon grease.
8. Close the oven and fix the cap with the screws.

   Indication! After mounting the permeation tube, the device should operate in purging stage for approx. 24 hours to get a constant span gas value from the permeation system.
9. Dispose the old tube. Take care for the notice at the packing.

4.5. Exchange permeation tube BTX

The useful life time of the tubes depends on the type of the tube and the permeation rate.

Danger! When exchange the tube harmful gases will be released. This work have to be done only in well ventilated area.

Danger! Hazard of burn of the skin.
In operation the oven is heated up to 50°C. For protection against burn of skin use suitable tolls or protective gloves.

Procedure

1. Open the case. Refer to item 4.2.
2. Loose 4 screws on the top of the heated block of the BTX permeation oven. Lift the cap.
3. Loose the cap on the inlet and outlet of the glass chamber and disconnect the teflon tubes.

   Indication! Inside of the glass chamber there is a thin glass pipe at the gas inlet. Be carefully for the next steps not to damage this pipe.
4. Lift the glass chamber out of the heated block.

5. Lift the upper part from the lower part of the glass chamber.
6. Remove the tubes. Storage the tubes at a well ventilated area to cool down.
7. Take the new tubes out of the package.

Danger! Take care for the notice on the package.

8. Fit the permeation tubes into the glass chamber and join the upper and lower part of the chamber.
9. Fit the glass chamber into the heated block. Take care that the thin glass pipe is on the gas inlet of the oven.
10. Connect the teflon tube on the gas inlet and outlet and screw the caps.
11. Close the oven and fix the cap with the 4 screws.

Indication! After mounting the permeation tube, the device should operate in purging stage for approx. 24 hours to get a constant span gas value from the permeation system.

12. Dispose the old tube. Take care for the notice at the packing.

5. Shut down

Indication! Apply the information in this chapter according to the stage of the existing device.

If the device is shut down for less than approx. 10 minutes no action is necessary.

For longer shut down periods than approx. 15 minutes or missing zero air supply remove the permeation tubes from the oven to avoid pollution caused by very high concentration in the oven.

Turn off the external zero gas supply and the gas cylinders and turn off the device with the power switch.

6. Regulations

EU regulations

Conformable standards

This equipment conforms to the following standards:

CE

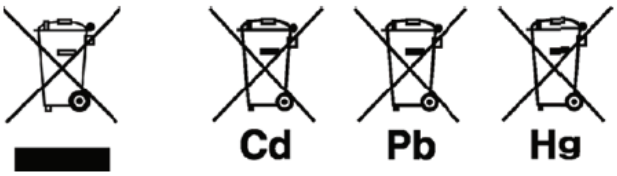
EMC:	EN 61326-1 Class B, Industrial electromagnetic envirnment
Safety:	EN 61010-1
RoHS:	EN 50581 9. Industrial monitoring and control instruments

Installation environment
This product is designed for the following environment.
• Overvoltage category II
• Pollution degree 2

Information on disposal of electrical and electronic equipment and disposal of batteries and accumulators

The crossed out wheeled bin symbol with underbar shown on the product or accompanying documents indicates the product requires appropriate treatment, collection and recycle for waste electrical and electronic equipment (WEEE) under the Directive 2012/19/EU, and/or waste batteries and accumulators under the Directive 2006/66/EC in the European Union. The symbol might be put with one of the chemical symbols below. In this case, it satisfies the requirements of the Directive 2006/66/EC for the object chemical.

This product should not be disposed of as unsorted household waste. Your correct disposal of WEEE, waste batteries and accumulators will contribute to reducing wasteful consumption of natural resources, and protecting human health and the environment from potential negative effects caused by hazardous substance in products. Contact your supplier for information on applicable disposal methods.



7. Technical Data

7.1. Technical data AFCU-360M

Power supply	:	230 V / 50Hz ± 10 %
Power consumption	:	see Test Report
Ambient temperature	:	5 - 35 °C
Control accuracy of heater	:	± 0,1 °C
Expansion stage	:	see Test Report
Pressure gas inputs	:	see Gas flow chart
Fittings	:	By default, for Teflon tube 6/4mm or stainless stell 1/8” for bottle input for special solutions see also Gas flow chart
SGG control	:	see Test Report
Dimension WxDxH	:	19", 570 mm, 3 HU
Weight	:	see Test Report

7.2. Technical data thermal mass flow controllers

Range	:	see Test Report
Reference temperature/pressure	:	0 °C / 1013,25 mbar
Outlet signal	:	0 – 5 V
Accuracy	:	± 1 % of full scale
Linearity	:	± 0,5 % of full scale
Repeatability	:	± 0,2 % of full scale