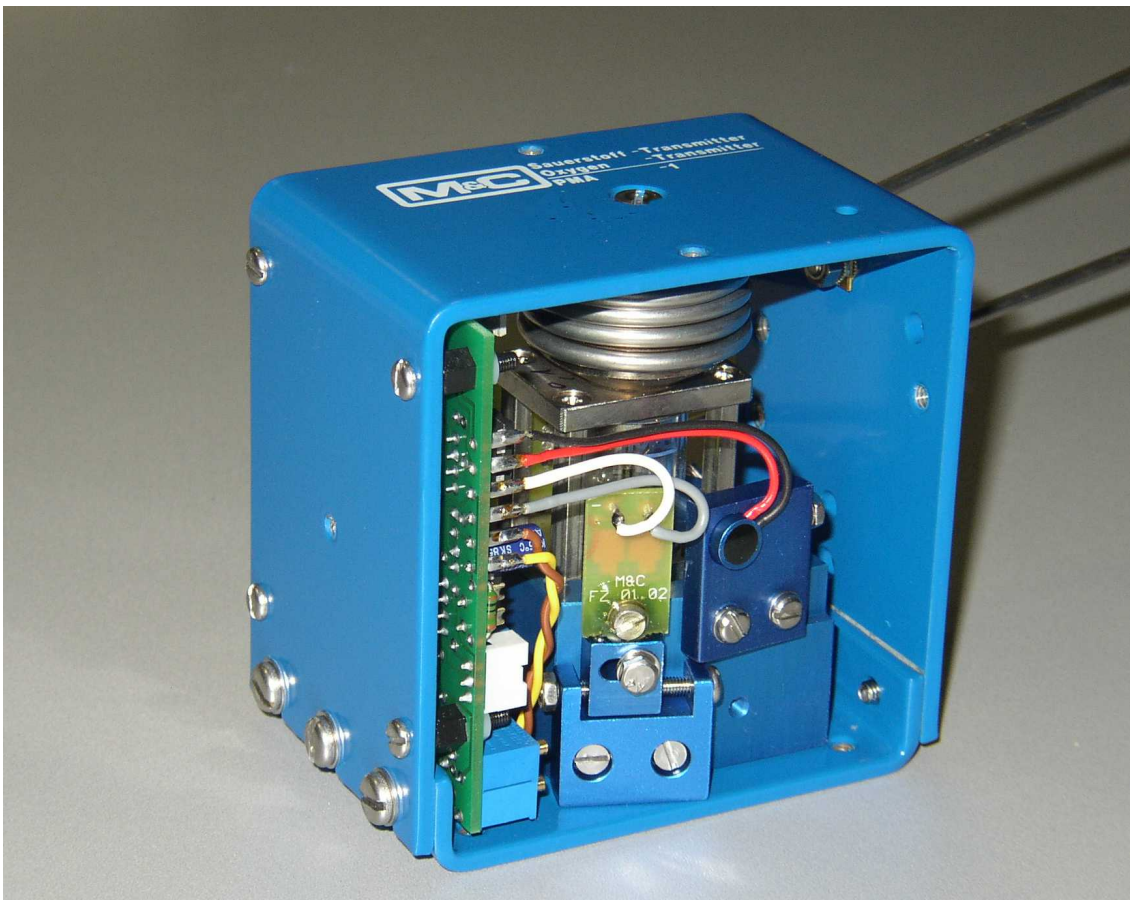
Embracing Challenge

General Hints for Operating and Mounting of M&C Oxygen Transmitters

Type PMA 1.xx

Version 1.00.01



Dear customer,

Thank you for buying our product. In this document you will find necessary information about this M&C product. The information in the document is fast and easy to find.

If you have any question regarding the product or the application, please don't hesitate to contact M&C or your M&C authorized distributor. You will find all the addresses in the appendix of this instruction manual.

For additional information about our products, please go to M&C's website www.mc-techgroup.com. There you can find the data sheets and manuals of our products in German and English.

Version: 1.00.01

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1 GENERAL INFORMATION

The product described in this document has been built and tested in our production facility.

All M&C products are packed to be shipped safely. To ensure the safe operation and to maintain the safe condition, all instructions and regulations stated in this document need to be followed. This document includes information regarding proper transportation, storage, installation, operation and maintenance of this product by qualified personnel.

Follow all instructions and warnings closely.

Read this document carefully before commissioning and operating the device. If you have any questions regarding the product or the application, please don't hesitate to contact M&C or your M&C authorized distributor.

2 SAFETY INSTRUCTIONS

Follow these basic safety procedures when mounting, starting up or operating this equipment:

Read this document before starting up and use of the equipment. The information and warnings given in this operating manual must be heeded.

Any work on electrical equipment is only to be carried out by trained specialists as per the regulations currently in force.

When connecting the device, ensure the correct supply voltage according to the data sheet.

The device is only to be used within the permitted range of temperatures and pressures.

Check that the location is weather-protected. It should not be subject to either dust, direct rain or moisture.

Do not use the device in hazardous areas.

Installation, maintenance, inspections and any repairs of the devices must be carried out only by qualified skilled personnel in compliance with the current regulations.

2.1 INTENDED USE

The M&C oxygen transmitters Type PMA 1.xx are intended for use in general purpose areas (non-hazardous environments). It may only be operated in compliance with the information in chapter 'Technical data' . Particularly you must meet the requirements of the ambient temperature and characteristics.
Do not use this product for any other purpose. Improper use and handling can create hazards and cause damage. For more information, please refer to the safety information in this document.

3 WARRANTY

In case of a device failure, please contact immediately M&C or your M&C authorized distributor.

We have a warranty period of 12 months from the delivery date. The warranty covers only appropriately used products and does not cover the consumable parts. Please find the complete warranty conditions in our terms and conditions.

The warranty includes a free-of-charge repair in our production facility or the free replacement of the device. If you return a device to M&C, please be sure that it is properly packaged and shipped with protective packaging. The repaired or replaced device will be shipped free of delivery charges to the point of use.

4 USED TERMS AND SIGNAL INDICATIONS

Danger

This means that death, severe physical injuries and/or important material damages **will occur** in case the respective safety measures are not fulfilled.

Warning

This means that death, severe physical injuries and/or important material damages **may occur** in case the respective safety measures are not fulfilled.

Caution

This means that minor physical injuries **may occur** in case the respective safety measures are not fulfilled.

Caution

Without the warning triangle means that a material damage may **occur** in case the respective safety measures are not met.

Attention

This means that an unintentional situation or an unintentional status **may occur** in case the respective note is not respected.

Note

These are important information about the product or parts of the operating manual which require user's attention.

Skilled Staff

These are persons with necessary qualification who are familiar with installation, use and maintenance of the product.

5 DESCRIPTION

The oxygen transmitters type PMA 1.xx are suitable for measurement of oxygen in dry, particle-free gases.

Due to the extremely fast response time of the M&C magneto-dynamic measuring cell with no stagnant volume as well as the negligible cross sensitivity from other sample gas components, the transmitters PMA 1.xx have a wide variety of applications.

They are a suitable and reliable instrument for monitoring oxygen concentrations in various gas analytical control applications including flue gas-, inert gas-, fermentation processes- and process or laboratory control measurements.

They are characterized by reliability, robustness, accuracy and low maintenance.

The physical measuring method is based on the magneto-dynamic oxygen measuring cell and is one of the most precise methods for oxygen measuring in a range of 0 to 100 vol% O_2.

The measuring cell has a low volume of only 2 ml, is very robust, has an extremely low drift and a very fast response time.

6 MEASURING PRINCIPLE

Oxygen is a gas with a significant paramagnetic susceptibility. The molecules of oxygen are attracted much more strongly by a magnetic field than the molecules of other gases.

The measuring principle shown in the following is benefitting from these characteristics of the oxygen. The great advantage of the paramagnetic measuring principle is the highly reduced cross sensitivity of the measurement to other components in the sample gas.

Figure 1 shows the diagram of the measuring cell as well as the optical system for the detection of the dumbbell's movement.

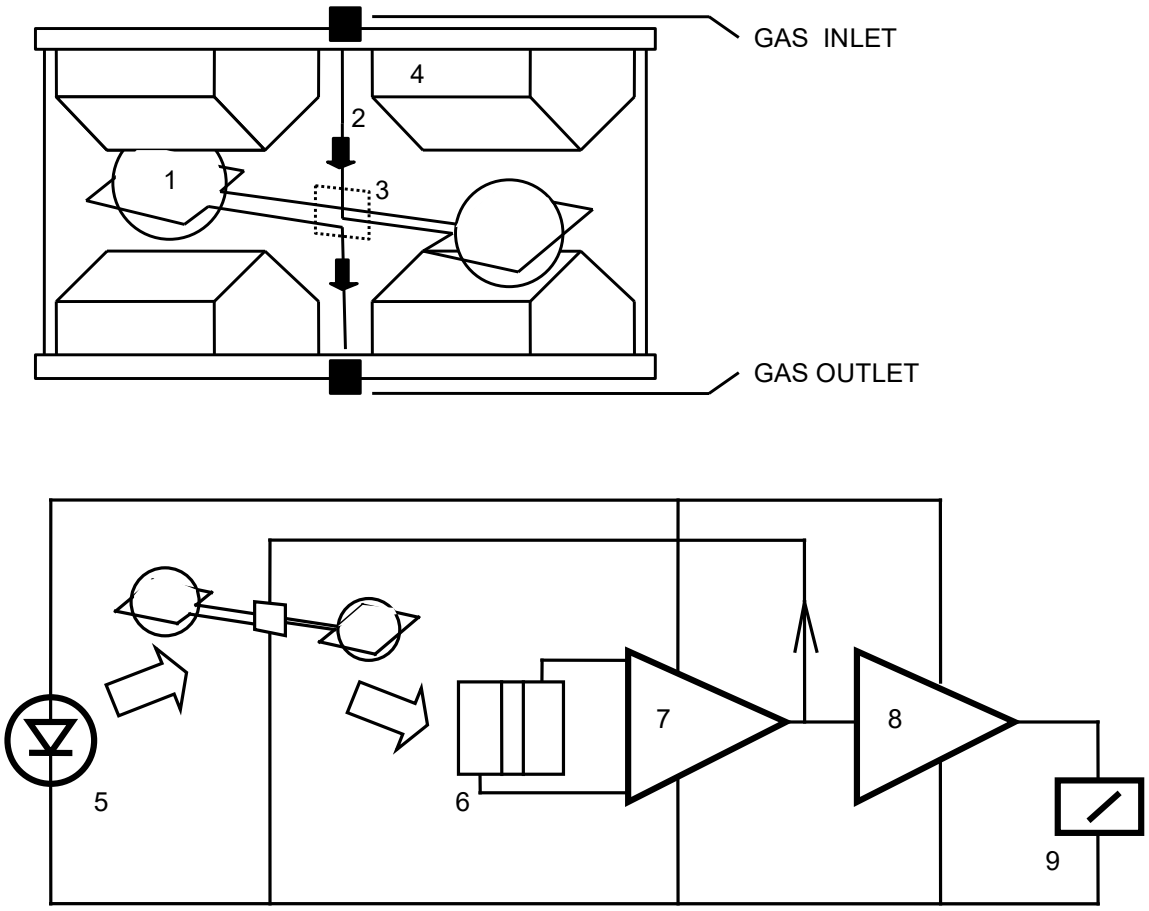


Figure 1 Scheme of the measuring cell and optical signal processing

① Two nitrogen-filled spheres
② Tightening strap out of platinum
③ Mirror
④ Two pole pieces
⑤ Projection LED
⑥ Photoelectric cell
⑦ Measuring amplifiers
⑧ Measuring amplifiers
⑨ Display

The measuring cell consists of two nitrogen-filled spheres ① which are arranged in the form of a dumbbell. In the dumbbell's central point of rotation, a small mirror ③ is placed. The dumbbell is surrounded by a wire coil needed for the compensation procedure. The described system is fixed rotationally symmetrical inside a glass tube via a tightening strap out of platinum ② and is screwed up with two pole pieces ④.

Two permanent magnets are producing an inhomogeneous magnetic field. When oxygen is flowing in, the molecules of the oxygen are drawn into the magnetic field. In consequence, the lines of electric flux on the cuneiform pole pieces ④ are compressed. The nitrogen-filled diamagnetic spheres are pushed out of the magnetic field. This causes a rotation of the dumbbell. The rotation is detected via an optical system consisting of mirror ③, projection LED ⑤ and photoelectric cell ⑥.
In case the dumbbell is pushed out of the magnetic field, the tension of the photoelectric cell is immediately changed. The measuring amplifiers ⑦ and ⑧ are producing a respective current which develops via the wire coil on the dumbbell an electro-magnetic load moment. The load moment is resetting the dumbbell into its zero position.

Every change of the oxygen concentration produces a lineary proportional change of the compensation current and can be read directly in % O_2 as oxygen value on the display ⑨.

Due to its very small stagnant volume (2 cm^3) and the direct flow of the **M&C** measuring cell, an extremely fast response time (T_{90}-time) of 1 second for a high gas flow can be realized.

7 TECHNICAL DATA

	Transmitter Type PMA 1.xx
Electrical connection	18-pin Dil-plug
Response time for 90% value	< 3 seconds at 60 Nl/h
Influence of barometric pressure	The oxygen reading varies in direct proportion to changes of the barometric pressure
Sample gas inlet pressure	Min. 0.01 bar, max. 1 bar g
Sample gas outlet pressure	Sample gas must discharge freely into atmosphere
Ambient- / sample gas temperature	-10 to +50 °C [14 to 122 °F]
Lagertemperatur	-20 to +60 °C [-4 to 140 °F]
Ambient humidity	0-95 % relative humidity
Media wetted material	Platin, glass, stainless steel SS316Ti, Viton, polypropylene, epoxy
Sample gas connections	Tube 1/8“ (3.2 mm)
Dimensions (H x W x L)	90 x 96.5 x 60 mm [≈ 3.5“ x 3.8“ x 2.4“]
Weight	1 kg [≈ 2.2 lbs]

More technical data you can find in the enclosed drawings and data sheets provided with the transmitter.

8 RECEIPT OF GOODS AND STORAGE

The oxygen transmitters type PMA 1.xx is a complete pre-installed unit.

- Please take the oxygen transmitters type PMA 1.xx and possible special accessories carefully out of the packaging material immediately after arrival, and compare the goods with the items listed on the delivery note.
- Check the goods for any damage caused during delivery and, if necessary, notify your transport insurance company without delay of any damage discovered.
- .

Note

The equipment should be stored in a protected, frost-free room!

9 MOUNTING

For mounting of the transmitter 4 holes M4 are provided in the bottom plate.

Attention When mounting take care that no mechanical vibrations can be transferred to the transmitter. If necessary use anti-vibration pads.
Mounting has to take place horizontally.

Attention For error-free operation the transmitters have to be protected surely against external light. For transmitters with heating a heat insulation is necessary. For both points the M&C insulation cap can be used.

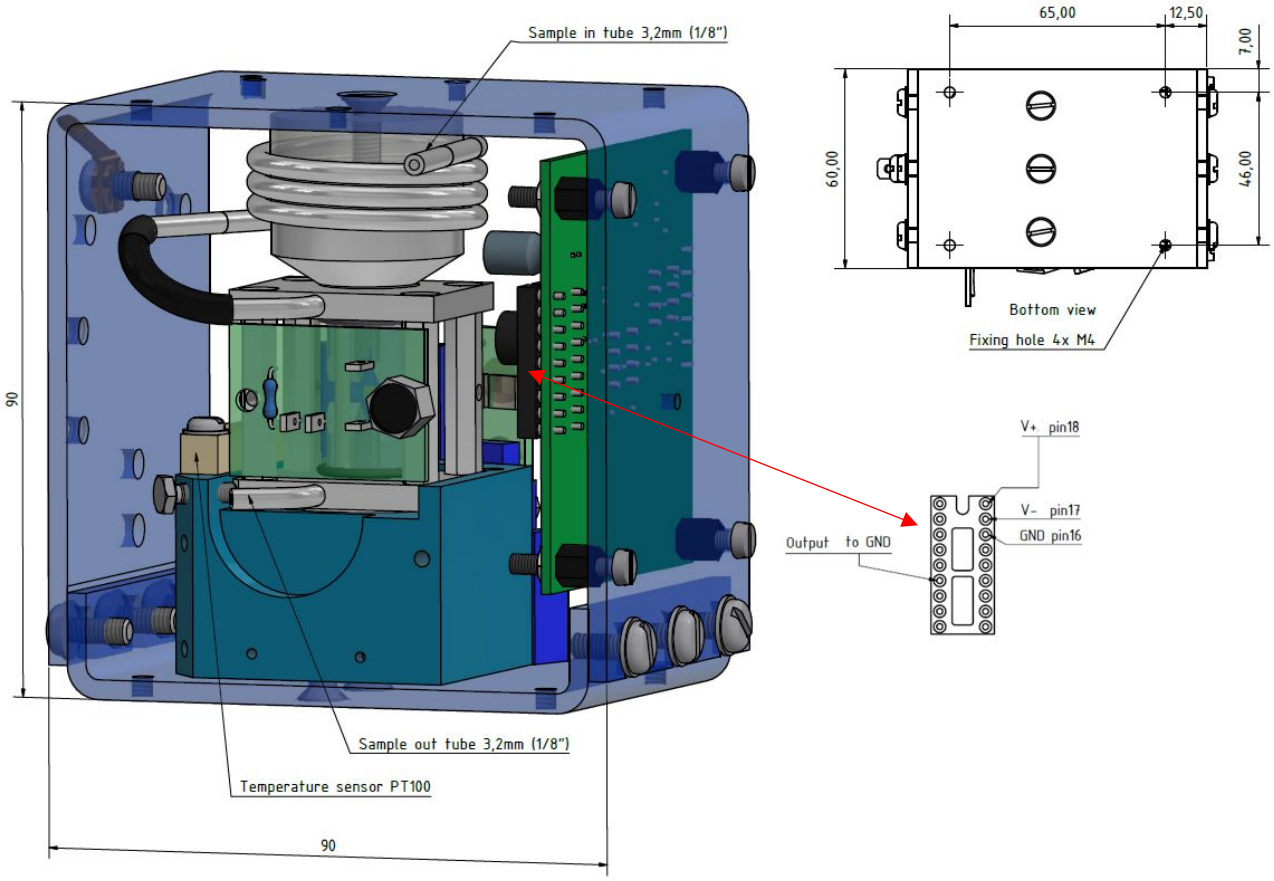


Figure 2 Dimension drawing transmitter

10 PNEUMATIC CONNECTION

Connection of sample gas with corresponding connectors or hoses takes place at the sample gas inlet Pos. 2 and sample gas outlet Pos. 3 (tube 3.2 mm outer diameter).

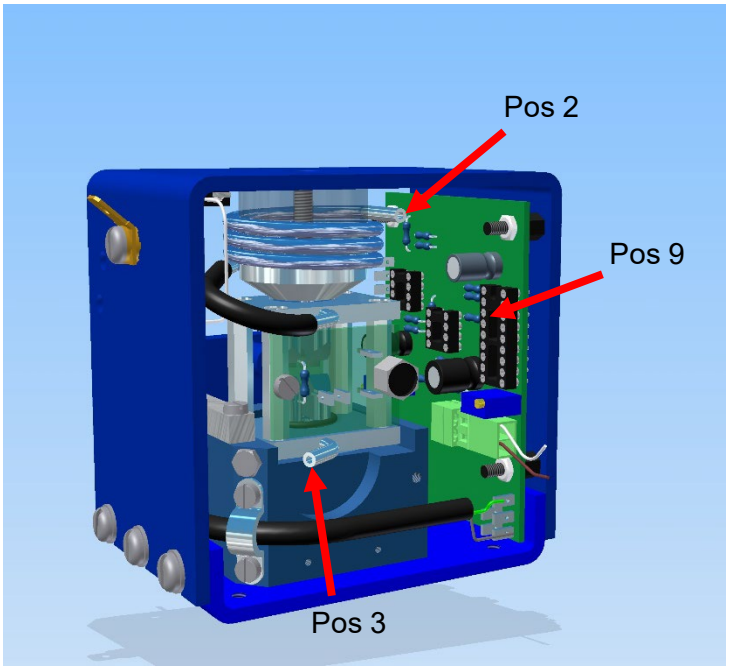


Figure 3 Pneumatic and electrical connections transmitter PMA 1.xx

11 ELEKTRISCHER ANSCHLUSS

The electrical connection of the M&C transmitter PMA1.xx takes place with the 18-pin DIL-plug Pos. 9 (Figure 3). Here supply of the transmitter and delivery of the measuring signal takes place.

Further for calibration purposes an adjustment possibility e.g. with potentiometer for zero and span has to be created. Some transmitter versions already have a potentiometer (pre-adjustment) for span on the amplifier board. See also the supplied device-specific circuit diagram for the respective transmitter.

The current for the heating dependent on the type of transmitter is 24 V DC or 115/230 V. For the 24 V version the temperature controller is part of the amplifier board. For the 115/230 V version a controller has to be provided externally. Dependent on the type a temperature sensor PT100 or KTY 11 is available. All versions with heating are equipped with a non-reversible temperature fuse 72 °C [161.6 °F].

12 START UP

When starting up the **M&C** oxygen transmitter **PMA 1.xx** in connection with an oxygen analyzer the following items have to be observed.

Check pneumatic connections before switching on the device.

Caution The sample gas has to be dust free and dry (5 °C [41 °F] dew point) to prevent a contamination and condensation in the measuring cell. If necessary, a dew point lowering with cooler or dryer has to be done.
Basically always connect a fine filter (e.g. type FP-2T, Part No. 01F1200) upstream.

Attention For error free operation the oxygen transmitters PMA 1.xx have to be operated at constant ambient temperature.

13 CALIBRATION

The safety instructions specific to the plant and process are to be consulted prior to any calibration work!

The accuracy of the measurement is dependent on the accuracy of the calibration of the transmitter.

The linearity of the measuring range allows a two-point calibration of zero and span.

The weekly calibration of the transmitter guarantees the required accuracy of the measurement. Because of the direct proportional addiction of the oxygen reading on the barometric resp. process pressure the calibration interval can be shortened accordingly at large pressure fluctuations.
In general, a calibration should be performed under measurement conditions, that means at constant flow rate, ambient temperature and barometric pressure.

Attention Avoid vibrations during calibration and measurement!

13.1 ZERO CALIBRATION

The zero calibration of the transmitter takes place with O_2-free gas e.g. Nitrogen (N_2) 5.0.

Adjust zero gas flow rate with needle valve or flowmeter to max. 60 Nl/h. The flow rate of the calibration gas should always correspond to the sample gas flow rate.

Wait approx. 30 sec. until the indication has stabilized.

If necessary adjust zero to 0 % with external zero potentiometer. The zero potentiometer then has to be in middle position. If the position is clearly differing from the middle position the mechanical zero has to be adjusted (see 13.1.1). If this is not possible anymore the measuring cell probably has to be changed.

13.1.1 MECHANICAL ZERO ADJUSTMENT

The mechanical zero is adjusted as follows:

- Feed zero gas as described under 13.1.
- Loosen fixing screw pos. 4 of the photocell support.
- Turn adjustment screw pos. 6 of the photocell clockwise or anticlockwise until at the signal outlet 0.0 vol% is indicated.
- Retighten fixing screw pos. 4 of the photocell support;

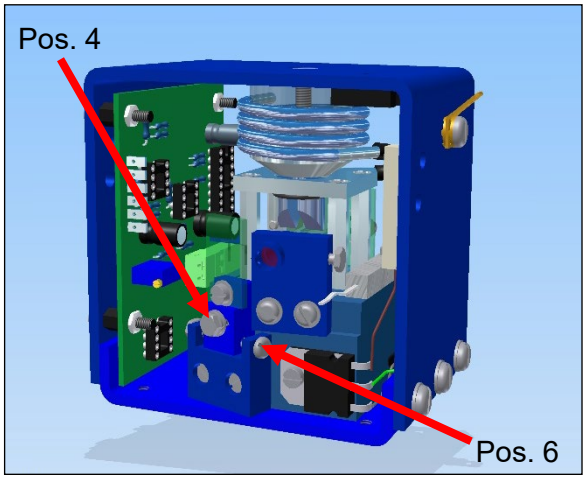


Figure 4 Adjustment of the mechanical zero

13.1.2 CROSS SENSITIVITIES

The following table shows the cross sensitivities of the most important gases at 20 °C [68 °F] and 50 °C [122 °F]. All values are based on a zero calibration with N_2 and a span calibration with 100 vol% O_2. The deviations are each valid for 100 vol% of the respective gas.

Gas	Molecular formula	20 °C [68 °F]	50 °C [122 °F]
Acetaldehyde	C_2H_4O	- 0,31	- 0,34
Acetone	C_3H_6O	- 0,63	- 0,69
Acetylene	C_2H_2	- 0,26	- 0,28
Ammonia	NH_3	- 0,17	- 0,19
Argon	Ar	- 0,23	- 0,25
Benzene	C_6H_6	- 1,24	- 1,34
Bromine	Br_2	- 1,78	- 1,97
Butadiene	C_4H_6	- 0,85	- 0,93
n-Butane	C_4H_{10}	- 1,10	- 1,22
Iso Butylen	C_4H_7	- 0,94	- 1,06
Chlorine	Cl_2	- 0,83	- 0,91
Diacetylene	$(CHCl)_2$	- 1,09	- 1,20
Nitrous monoxide	N_2O	- 0,20	- 0,22
Ethane	C_2H_4	- 0,43	- 0,47
Ethylbenzene	C_8H_{10}	- 1,89	- 2,08
Ethylene	C_2H_4	- 0,20	- 0,22
Ethylene glycol	$(CH_2OH)_2$	- 0,78	- 0,88
Ethylene oxide	$C_2H_4O_2$	- 0,54	- 0,60
Furan	C_4H_4O	- 0,90	- 0,99
Helium	He	+ 0,29	+ 0,32
n-Hexane	C_6H_{14}	- 1,78	- 1,97
Hydrogen chloride	HCL	- 0,31	- 0,34
Hydrogen fluoride	HF	+ 0,12	+ 0,14
Hydrogen sulfide	H_2S	- 0,41	- 0,43
Carbon dioxide	CO_2	- 0,27	- 0,29
Carbon monoxide	CO	- 0,06	- 0,07
Krypton	Kr	- 0,49	- 0,54
Methane	CH_4	- 0,16	- 0,17
Methanol	CH_4O	- 0,27	- 0,31
Methylen chloride	CH_2Cl_2	- 1,00	- 1,10
Methyl propene	C_4H_8	- 0,94	- 1,06
Monosilan	SiH_4	- 0,24	- 0,27
Neon	Ne	+ 0,16	+ 0,17
n-Octane	C_8H_{18}	- 2,45	- 2,70
Phenol	C_6H_6O	- 1,40	- 1,54
Propane	C_3H_8	- 0,77	- 0,85
Propylene	C_3H_6	- 0,57	- 0,62
Propylene chloride	C_3H_7Cl	- 1,42	- 1,44
Propylene oxide	C_3H_6O	- 0,90	- 1,00
Oxygen	**O_2**	**+100,00**	**+100,00**
Sulfur dioxide	SO_2	- 0,18	- 0,20
Sulfur fluoride	SF_6	- 0,98	- 1,05
Monosilane	SiH_4	- 0,24	- 0,27
Nitrogen	**N_2**	**0,00**	**0,00**
Nitrogen dioxide	NO_2	+ 5,00	+ 16,00
Nitrogen monoxide	NO	+ 42,70	+ 43,00
Styrene	C_8H_8	- 1,63	- 1,80
Toluene	C_7H_8	- 1,57	- 1,73
Vinyl chloride	C_2H_3Cl	- 0,68	- 0,74
Vinyl fluoride	C_2H_3F	- 0,49	- 0,54
Water (Steam)	H_2O	- 0,03	- 0,03
Hydrogen	H_2	+ 0,23	+ 0,26
Xenon	Xe	- 0,95	- 1,02

13.1.3 CONSIDERATION OF CROSS SENSITIVITIES

The selectivity of the above mentioned measuring principle is based on the high susceptibility of oxygen to other gases (see table).

The following examples shall show how cross sensitivities can be considered for the zero calibration.

Example 1: Determination of the rest content of oxygen in a 100 % carbon dioxide (CO_2) protective atmosphere at 20 °C

In the table of cross sensitivities you can read the value for CO_2 at 20 °C of –0.27. This means that for calibration with nitrogen the zero point must be set to +0.27 % in order to compensate the deviation of the display.

In this example, the atmosphere contains exclusively CO_2 and O_2. For this reason, the influence of cross sensitivity can be eliminated without problem by using carbon dioxide (CO_2) instead of nitrogen for the zero calibration.

Example 2: Determination of the oxygen content of a gas mixture at 20 °C [68 °F]

1 vol% C_2H_6 (Ethane);
5 vol% O_2;
40 vol% CO_2;
54 vol% N_2.

Zero point calibration with nitrogen (N_2).

The cross sensitivity values of above table are based on 100 vol% of the respective gases. Therefore, a conversion must be made to the effective volume concentration. In principle, the following is valid:

$$\text{Effective cross sensitivity} = \frac{\text{Table value} * \text{Volume concentration}}{100} \quad [\text{vol\%}]$$

For the components of the gas mixture, the following values are found:

C_2H_6 : -0.0043 vol%;

CO_2 : -0.1080 vol%;

N_2 : 0.0000 vol%.

$\sum$ = -0.1123 vol%

To determine the sum of cross sensitivity as exactly as possible, a correction factor has to be determined, because the sum of cross sensitivities relates not on 100 % but on 100 % minus the oxygen concentration (here 95 %).

The correction factor is calculated as follows:

$$\text{Correction factor} = \frac{100}{(100 - O_2\text{-concentration})}$$

It is incidental:

$$\frac{100}{(100 - 5)} = \underline{1.0526}$$

For the gas mixture the rectified sum cross sensitivity then is calculated in good approximation:

1.0526 x -0.1123 Vol.% = <u>-0.1182 vol%</u>

The rectified sum cross sensitivity with change of sign now can be used for the correction of the zero calibration. In this case zero had to be adjusted at +0.1182 vol%.

In case the cross sensitivities should be ignored in the above mentioned example, this would result in a relative error of approximately 2 %.

Note

After zero calibration the span has to be calibrated too.

13.2 SPAN CALIBRATION

Before span calibration a finished zero calibration is necessary.

The procedure for calibration is as follows:

- Adjust test gas flow rate with needle valve or flowmeter to max. 60 Nl/h. The flow rate of the calibration gas should always correspond to the sample gas flow rate.
- Wait approx. 30 sec. until the indication has stabilized.
- If necessary adjust span with external span potentiometer (for air to 20.9 %)

14 CLEANING

Note

With external contamination clean transmitter with soap sud moistened cloth only.

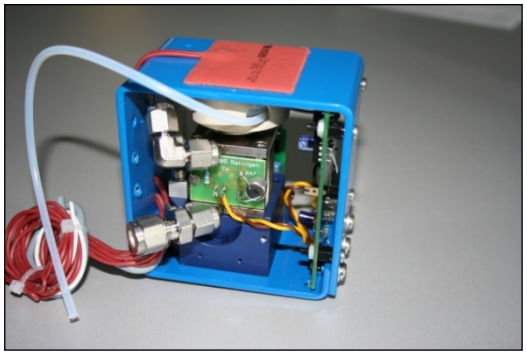
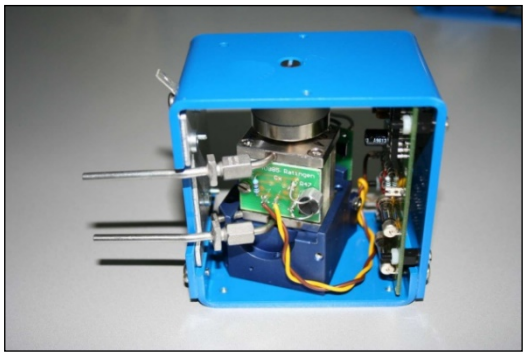
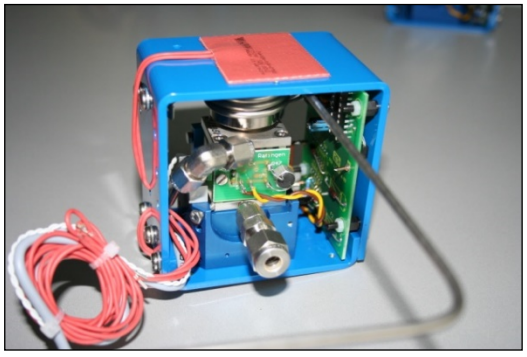
15 CLOSING DOWN

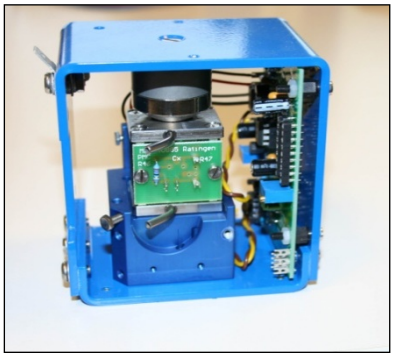
In case of a closing down of the transmitter for a longer period, it is recommended to flush the analyzer with dry and clean inert gas (e.g. Nitrogen) in order to prevent a damage of the measuring cell by aggressive and corrosive liquid gases.

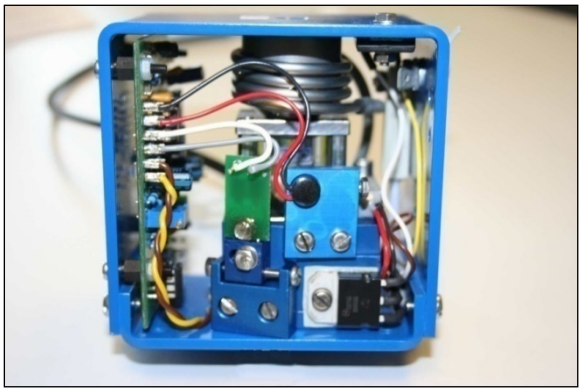
16 PROPER DISPOSAL OF THE DEVICE

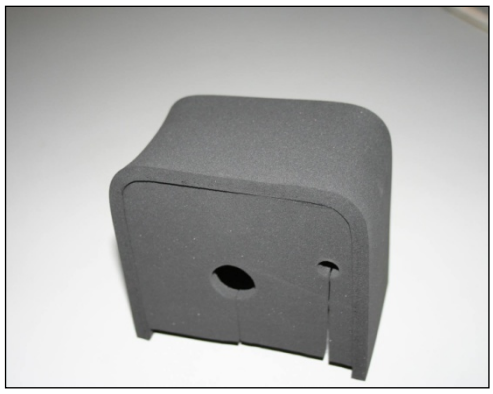
At the end of the life cycle of our products, it is important to take care of the appropriate disposal of obsolete electrical and non-electrical devices. To help protect our environment, please follow the rules and regulations of your country regarding recycling and waste management.

17 OVERVIEW OF THE DIFFERENT TRANSMITTER VERSIONS

Sample gas connection and pre-heater versions	
 C1	Connection sample gas inlet and sample gas outlet : pipe nipple 1/8“ Material pre-heater : stainless steel Connection from pre-heater to measuring cell : FKM-tube
 C2	Connection Sample gas inlet: 1/8“ PTFE tube Sample gas outlet: 1/8“ tube with adapter for 6mm pipe or tube outer diameter Material pre-heater : PTFE Connection from pre-heater to measuring cell : stainless steel
 C3	Connection sample gas inlet and sample gas outlet: pipe nipple 1/8“ No pre heater
 C4	Connection Sample gas inlet: 1/8“ stainless steel tube Sample gas outlet: 1/8“ tube with adapter for 6mm pipe or tube outer diameter Material pre-heater : PTFE Connection from pre-heater to measuring cell : stainless steel

Sample gas connection and pre-heater versions	
 C5	Connection sample gas inlet and sample gas outlet: pipe nipple 1/8“ directly at the measuring cell No pre-heater

Heater versions	
 H1	Two heater 115 V, 12 W mounted outside at the transmitter. Temperature fuse and temperature sensor mounted inside of the transmitter. External controller is necessary.
 H2	Heater 24 V DC, 1 A Temperature fuse, temperature sensor and temperature controller mounted inside of the transmitter.

Accessory	
	Insulation cover
	18-pin DIL-connection cable

Measuring amplifier
Transmitter PMA 10 Supply voltage ±12 V DC Voltage regulator on the measuring amplifier ±9 V With measuring range switching 0-1, 3, 10, 30, 100, output 0-1 V External selector switch, zero and span potentiometer (not in the range of delivery) With mA-amplifier 0/4-20 mA for chosen measuring range Measuring range independent output 0-1 V for 0-100 % O_2
Transmitter PMA 20 Supply voltage ±15 V DC Voltage regulator on the measuring amplifier ±12 V With measuring range switching 0-1, 3, 10, 30, 100, output 0-1 V External selector switch, zero and span potentiometer (not in the range of delivery) With mA-amplifier 0/4-20 mA for chosen measuring range Measuring range independent output 0-1 V for 0-100 % O_2
Transmitter PMA Ma1 Supply voltage ±15 V DC stabilized current consumption ±40 mA Output 0-10 V for 0-100 % O_2
Transmitter PMA Ma2 Supply voltage ±15 V DC stabilized current consumption ±40 mA Output 0-10 V for 0-100 % O_2 With heating controller 24 V DC current consumption 1.2 A max
Transmitter EXi External wiring for generation of the output signal necessary. 0-1 V for 0-100 % O_2 The measuring cell circuit is separated intrinsically safe via two zener barriers. This means gases of zone 0 are allowed to be measured with this transmitter. Intrinsic safety is certified via the EC-type examination KEMA 03ATEX1505U. Ⓔx II (1) G [EExia] IIC