Embracing Challenge

Manual

Oxygen transmitter Model PMA 05

Dear Customer,

We have organised this manual to enable you to find and understand all the necessary information about the product quickly and easily.
If nevertheless you should still have questions regarding the product or its use, do not hesitate to contact us directly at **M&C**, or your local dealer. Contact addresses can be found in the appendix to this manual.
Please also consult our homepage **www.mc-techgroup.com** for further information about our products. There you will find the manuals and product data sheets for all **M&C** products and other information in German, English and French for download.

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Contents

List of figures

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1 GENERAL INFORMATION

The product described in this guide has been supplied in a safe and tested condition. For safe operation and to maintain this condition, the information and instructions in this guide must be followed. In addition, the appropriate transportation, proper storage and installation as well as careful operation and maintenance are necessary.
For the proper use of this product, all information required for technical personnel is contained in this manual.

2 SAFETY INSTRUCTIONS

Please note the following basic safety precautions when using the device:

- Read the manual before operation and use of the equipment! The instructions and warnings in the manual must be followed.
- Work on electrical equipment may only be performed by qualified personnel in accordance with the regulations currently in force.
- When connecting the device, ensure the correct supply voltage according to the datasheet.
- Use the device only in the permitted temperature ranges.
- Ensure installation is weather-protected. Do not directly expose to dust, rain or liquids.

3 WARRANTY

If the equipment fails, please contact **M&C** directly, or your authorised M&C dealer.
Provided that the device is used correctly, we undertake to provide a 1 year warranty from the date of delivery according to our terms of sale. Consumables are not covered by the warranty. The warranty covers free repair at the factory or free replacement of the device sent free to the point of use. Returns must be made in sufficient and proper protective packaging.

4 TERMINOLOGY AND SYMBOLS USED

DANGER!	means that death, serious personal injury and/or substantial property damage **will** result if proper precautions are not taken.
WARNING!	indicates that death, serious personal injury and/or substantial property damage **might** occur if proper precautions are not taken.
CAUTION!	means that minor personal injury **may** result if proper precautions are not taken.
CAUTION!	without a warning triangle symbol, indicates that property damage **may** result if proper measures are not taken.
ATTENTION!	indicates that an undesirable result or an undesirable situation **may** occur if the corresponding instructions are not followed.
NOTICE!	This is important information about the product or the appropriate part of the manual to which particular attention should be paid.
SPECIALIST PERSONNEL	These are persons who are familiar with the installation, use, maintenance, and operation of the product and have the necessary skills through training or instruction.

5 DESCRIPTION

M&C PMA 05 oxygen transmitters are suitable for continuous oxygen measurements in dry and particle-free gases.

Due to the extremely fast response time, low stagnant volume, magneto-dynamic measuring cell with negligible cross-sensitivity to other sample gas components, **M&C 05 PMA** oxygen transmitters can be used in almost all applications.

They are a suitable and reliable analyser unit for oxygen monitoring in different processes, such as flue gas monitoring, inerting systems, fermentation processes, process and laboratory measurements, etc.

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

The physical measurement method is based on the magneto-dynamic oxygen cell and is one of the most accurate methods for the determination of oxygen in the range of 0-100% Vol.% O_2.

The measuring cell has a low volume of only 2 ml and thus a very rapid response time. In addition, it is subject to an extremely low drift.

6 TECHNICAL SPECIFICATIONS

	PMA05 MB10	PMA05 MB01
Part No.	**01A0510** (lowest measuring range 0-10 vol.% O_2)	**01A0520** (lowest measuring range 0-1 vol.% O_2)
Measuring range	0-100 vol% O_2 (standard), other measuring ranges according to client requirements	0-25 vol% O_2 (standard), other measuring ranges according to client requirements
Measurement output	0-10V DC non-isolated and 4-20mA for the chosen range, non-isolated, max. load 300Ω	
Time for 90% value	<3 seconds at 60 l/h	
Influence of barometric pressure	the O_2 display varies proportionally with barometric pressure.	
Heating according to each selected transmitter	55 ° C	
Temperature status contact on transmitters with heating	Contact load max. 48V 1A AC/DC Contact closes at Temp. > 50 ° C	
Accuracy after calibration	deviation: analogue signal output = ±1% of span at range 3-100% / digital indicator = ±0,1 vol.% O_2 analogue signal output = ±2% of span at range 1%	
Sample gas outlet pressure	the sample gas must flow without pressure out to atmosphere.	
Influence of sample gas flow	variation in gas flow between 0-60 Nl/hr air will cause a difference of < 0,1 vol.% O_2	
Flow rate of sample gas	max. 60Nl/hr	
Influence of ambient temperature	no influence up to +45°C	
Ambient/measurement gas temperature	-10 ° C to +45 ° C	
Storage temperature	-20 ° C to +60 ° C.	
Ambient humidity	0-95% RH.	
Electrical connection	12-pin connector	
Power supply	24V DC max. 1.5A	
Materials in contact with medium	Platinum, glass, stainless steel 1.4571, viton, polypropylene, epoxy	
Gas connections	Hose connection 4/6, other possible	
Dimensions	115 x 115 x 112 mm (HxWxL)	
Weight	1kg	
Options		
PT100 for thermostated version for temperature display or monitoring		
Other measuring range than standard range		
Zero suppression for spreading of measuring range		

For more technical data please refer to the data sheets of your chosen transmitter.

7 MEASUREMENT METHOD

Oxygen is a gas with strong paramagnetic properties. The molecules of the oxygen will be influenced more than that of most other gases by a magnetic field.
The measuring method presented below takes advantage of these properties of oxygen. The great advantage of the paramagnetic measuring principle is the greatly reduced cross-sensitivity of measurement to the other components in the sample gas.

Figure 2 shows the diagram of the measuring cell, as well as the optical system, for detecting motion of the dumbbell.

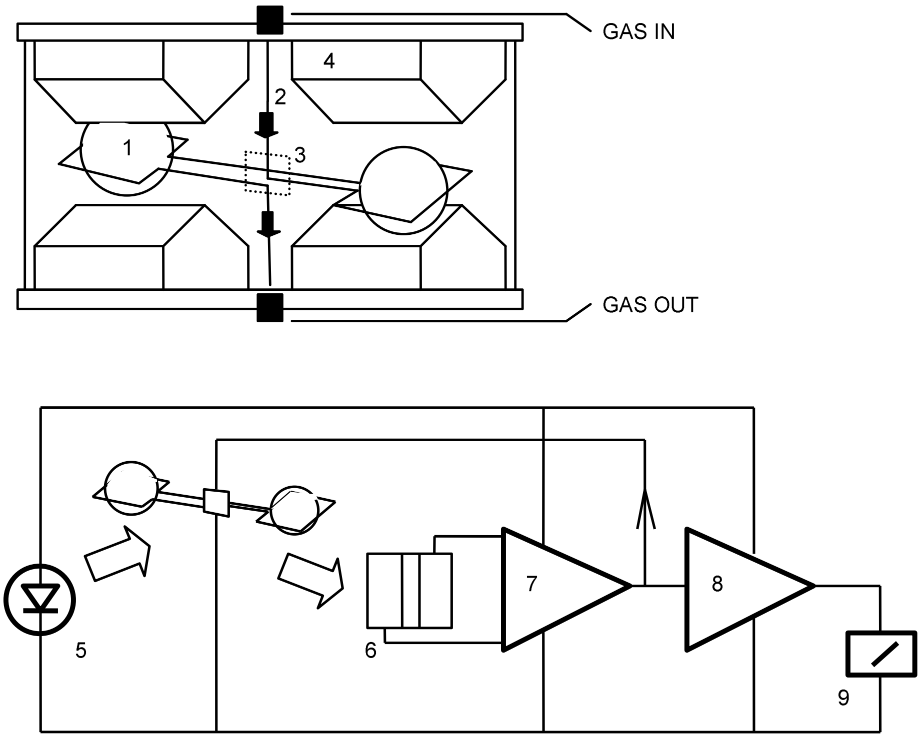

Illustration 1 Diagram of the measurement cell, and optical signal processing

The measuring cell consists of two nitrogen-filled hollow microspheres①, which are formed by a web on the dumbbell. In the centre of rotation of the dumbbell there is a small mirror③. The dumbbell is surrounded by a wire loop which is required for the compensation method. The above system is fixed by a platinum strap②rotationally symmetrical in a glass tube and screwed with two pole④pieces.

Two permanent magnets generate an inhomogeneous magnetic field. When oxygen flows in, the oxygen molecules are drawn into the magnetic field. There is compression of the field lines of the wedge-shaped pole pieces④. The nitrogen-filled diamagnetic hollow microspheres are pushed out of the magnetic field. This produces a rotational movement of the dumbbell. The rotary movement is detected by means of an optical system consisting of mirrors③, projection LED⑤and ⑥photocell.
If the dumbbell is forced out of the magnetic field, the voltage of the photocell changes immediately. The amplifiers (7)⑦ and ⑧(8) generate a corresponding current, which generates via the wire loop on the dumbbell an electromagnetic countermoment. The countermoment returns the dumbbell back to its zero position.

Any change in the oxygen concentration causes a linearly proportional change in the compensation current and hence can be read directly as the oxygen value in % O_2 ⑨on a display. Due to the very low stagnant volume (2 cm^3) and the direct flow of the **M&C** measuring cell, an extremely fast response time (T_{90} time) of the measuring cell of 1 second can be achieved at a high gas flow rate.

8 ASSEMBLY

In the bottom panel of the transmitter four M4 holes are provided for mounting.

ATTENTION! **When mounting, ensure that no mechanical vibrations can be transmitted to the transmitter.**
Installation must be horizontal.

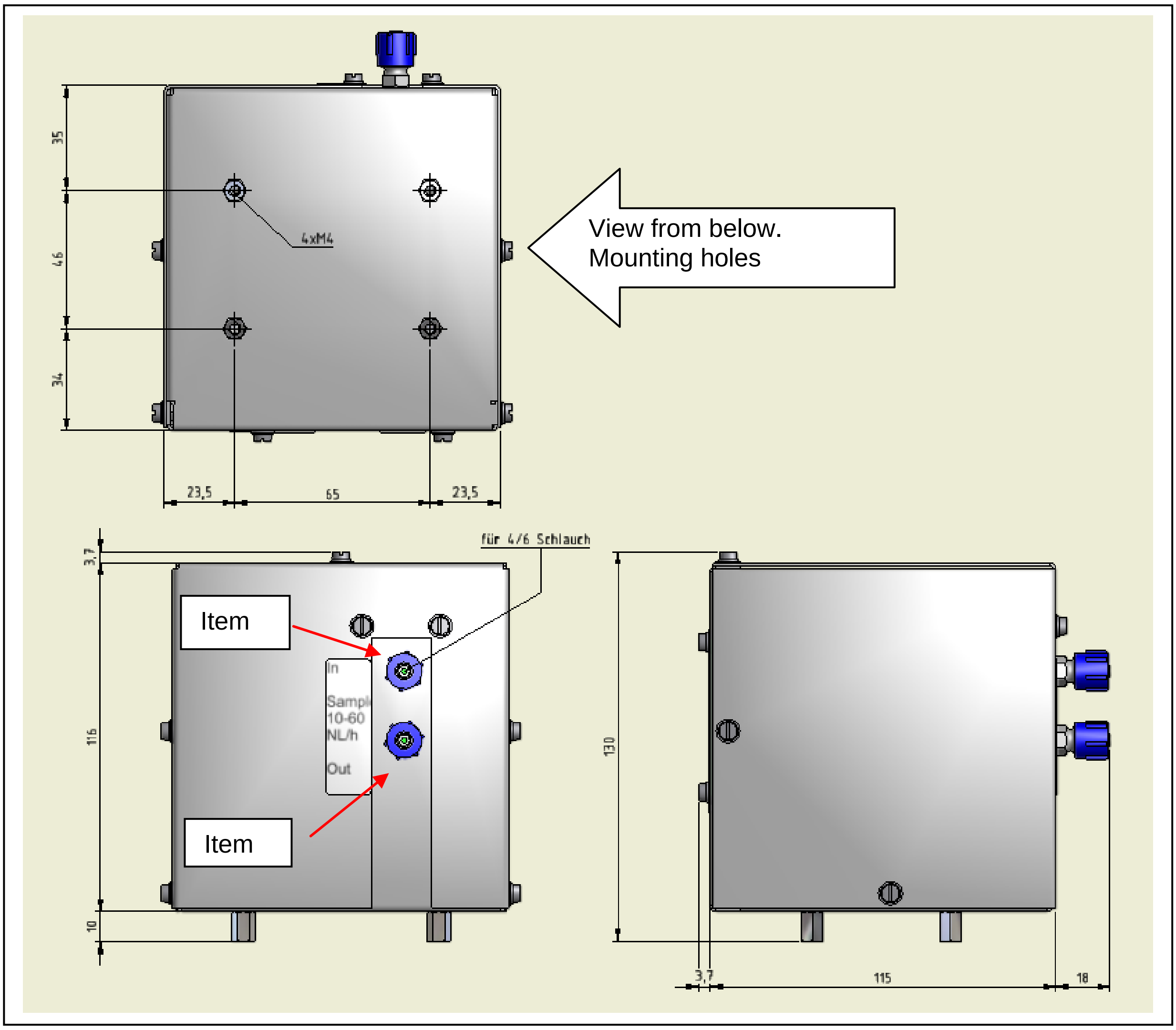

Illustration 2 Dimensions

9 PNEUMATIC CONNECTION

The sample gas is connected via DN4/6 hoses on the sample gas inlet item 2 and on the sample gas outlet item 3.

10 ELECTRICAL CONNECTION

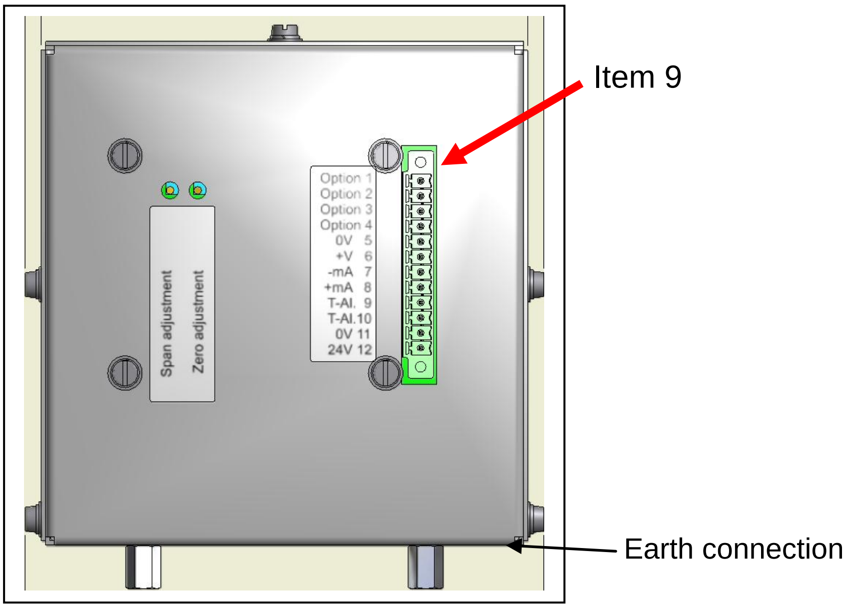

Illustration 3 Electrical connections transmitter PMA 05

The electrical connection of the **M&C** PMA 05 oxygen transmitter is via the 12-pin. plug Item 9 (Figure 3). This is where the transmitter receives power and the measurement signal is transferred.

Terminal 11 + 12: Supply voltage 24V DC (max. 1.5 A) for heating and transmitter

Terminal 9 + 10: Temperature status contact for all versions with heating, in addition, these versions have a non-reversible thermal fuse 72 °C

Terminal 7 + 8: Signal output 4-20mA (galvanically isolated) for the ordered measuring range e.g. 0-100% O_2

Terminal 5 + 6: Signal output 0 - 10V (galvanically isolated) for 0 - 100% O_2

Terminal 1 - 4 there are 4 terminal points available for optional features such as a PT100.

11 COMMISSIONING

The following points must be taken into consideration on commissioning the **M&C PMA 05** oxygen transmitter in conjunction with an oxygen analyser.

Before switching on the device, check the electrical and pneumatic connections.

CAUTION! **The sample gas must be dust-free and dry in order to avoid contamination and the dew point not being reached in the measuring cell. If required, a reduction in the dew point can be made using a cooler or drier.**

Always install upstream a fine filter with at least 2 µm filtration (e.g. type FP-2T, Art. No. 01F1200).

ATTENTION! **For correct operation, the PMA 05 oxygen transmitter may be operated at a constant ambient temperature.**

If the transmitter is equipped with heating, the measurement gas should be applied only after heating of the transmitter. Temperature status contact closed.

12 CALIBRATE

Before performing calibrations, the system and process-specific safety measures must be observed!

The measurement accuracy depends on the accuracy of the calibration of the transmitter.

The linearity of the measuring ranges enables two-point calibration of the zero point and the measuring range end value.

The weekly calibration of the transmitter guarantees the required measurement precision. Because of the direct proportional relationship between oxygen indication and barometric or process pressure, in the event of major pressure variations, the calibration interval may be shortened accordingly.
Calibration should be carried out under measurement conditions, i.e. at a constant flow rate, room temperature and at constant barometric pressure.

ATTENTION! **Avoid vibrations during calibration and during measurement!**

12.1 ZERO POINT CALIBRATION

Zero point calibration of the transmitter takes place with an O_2-free gas, such as nitrogen (N2) 5.0.

- Set the zero gas flow rate with a needle valve or flow metre to a maximum of 60 l/h. The flow rate of the calibration gas should always be adapted to the measurement-gas flow rate;
- Wait for approx. 30 seconds until the display has stabilised.
- If necessary, adjust the zero point with the zero point potentiometer to 0% = 4mA. The zero point potentiometer must then be located approximately in the central position. If the position of the zero point potentiometer deviates grossly from the centre position, the mechanical zero point must be corrected (see 12.1.1). Should this no longer be possible, the measuring cell is expected to be replaced.

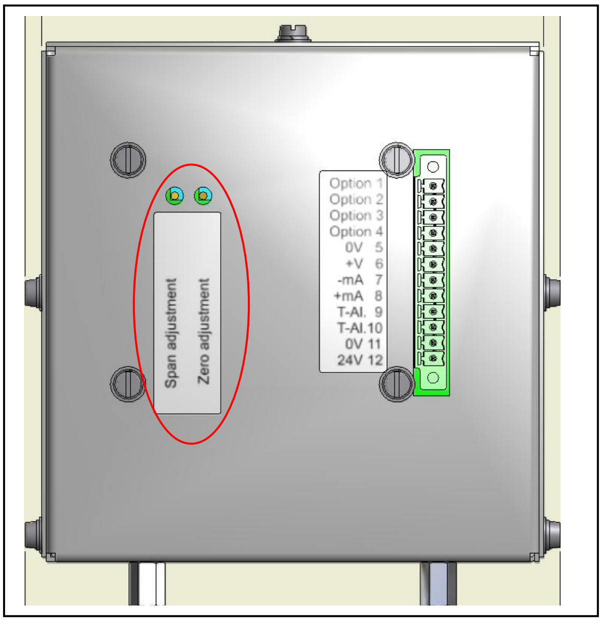

Illustration 4 Calibration

12.1.1 MECHANICAL ZERO POINT ADJUSTMENT

The mechanical zero point is set as follows:

- Assign zero gas as described in 13.1.
- Loosen fixing screw Item 4 of the photocell bracket.
- Turn the adjustment screw Item 6 of the photocell clockwise or counter-clockwise until 0.0% oxygen is indicated at the signal output;
- Retighten fixing item 4 of the photocell bracket;

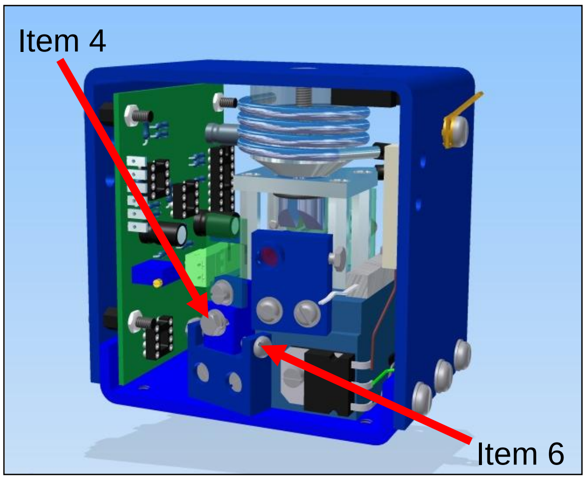

Illustration 5 Setting the mechanical zero point

12.1.2 INTERFERENCE EFFECTS

The following list shows the cross-sensitivity of the major gases at 20 °C and 50 °C. All values are based on zero point calibration with N_2 and end value calibration at 100% Vol. %O2. The deviations apply as appropriate for 100% Vol. of the corresponding gas.

Gas	Formula	20° C	50 °C
Acetaldehyde	C_2H4O	- 0.31	- 0.34
Acetone	C_3H6O	- 0.63	- 0.69
Acetylene	C_2H2	- 0.26	- 0.28
Ammonia	NH_3	- 0.17	- 0.19
Argon	Ar	- 0.23	- 0.25
Benzene	C_6H6	- 1.24	- 1.34
Bromine	Br_2	- 1.78	- 1.97
Butadiene	C_4H6	- 0.85	- 0.93
n-butane	C_4H10	- 1.10	- 1.22
Iso butylene	C_4H7	- 0.94	- 1.06
Chlorine	Cl_2	- 0.83	- 0.91
Diacetylene	$(CHCl)_2$	- 1.09	- 1.20
Nitrous oxide	N_2O	- 0.20	- 0.22
Ethane	C_2H4	- 0.43	- 0.47
Ethylbenzene	C_8H10	- 1.89	- 2.08
Ethylene	C_2H4	- 0.20	- 0.22
Ethylene glycol	(CH_2OH) 2	- 0.78	- 0.88
Ethylene	C_2H4O2	- 0.54	- 0.60
Furan	C_4H4O	- 0.90	- 0.99
Helium He	+ 0.29	+ 0.32	
n-hexane	C_6H14	- 1.78	- 1.97
Hydrogen chloride	HCL	- 0.31	- 0.34
Hydrogen fluoride	HF	+ 0.12	+ 0.14
Hydrogen sulphide	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	- 027	- 0.31
Methylene chloride	CH_2Cl2	- 1.00	- 1.10
Methylpropene	C4H_8	- 0.94	- 1.06
Monosilane	SiH_4	- 0.24	- 0.27
Neon	Ne	+ 0.16	+ 0.17
n-octane	C_8H18	- 2.45	- 2.70
Phenol C6H6O	- 1.40	- 1.54	
Propane	C_3H8	- 0.77	- 0.85
Propylene	C_3H6	- 0.57	- 0.62
Propylene chloride	C_3H7Cl	- 1.42	- 1.44
Propylene oxide	C_3H6O	- 0.90	- 1.00
Oxygen	**O_2**	**+100.00**	**+100.00**
Sulfur dioxide	SO_2	- 0.18	- 0.20
Sulphur hexafluoride	SF_6	- 0.98	- 1.05
Silane	SiH_4	- 0.24	- 0.27
Nitrogen	**N_2**	**0.00**	**0.00**
Nitrogen dioxide	NO_2	+ 5.00	+ 16.00
Nitrogen (mon)oxide	NO	+ 42.70	+ 43.00
Styrene	C_8H8	- 1.63	- 1.80
Toluene	C_7H8	- 1.57	- 1.73
Vinyl chloride	C_2H3Cl	- 0.68	- 0.74
Vinyl fluoride	CH_3F	- 0.49	- 0.54
Water (vapour)	H2O	- 0.03	- 0.03
Hydrogen	H_2	+ 0.23	+ 0.26
Xenon	Xe	- 0.95	- 1.02

12.1.3 CONSIDERATION OF CROSS-SENSITIVITIES

The selectivity of the above-mentioned measurement method is based on the great susceptibility of oxygen to other gases (see table).
The following examples are intended to show how cross-sensitivities can be taken into account in zero point calibration.

Example 1: Determining the residual oxygen content in 100% carbon dioxide (CO_2) inert gas atmosphere at 20 ° C.

From the table for CO_2 at 20° C, a value of -0.27 can be read for cross-sensitivity. This means that during calibration with nitrogen, the zero point must be set to 0.27% in order to compensate for the display declination in good approximation.

Since in this example there is only an atmosphere consisting of CO_2 and O_2, the interference effect can be eliminated easily by using carbon dioxide (CO_2) for zero point calibration instead of nitrogen (N2),

Example 2: Determining the oxygen content of a gas mixture at 20 °C.

1 vol% C_2H6 (ethane);
5 vol% O_2;
40 vol% CO_2;
54 vol% N_2.

Zero point calibration with nitrogen (N_2).

The cross-sensitivity values in the above table are based on 100% by volume of the corresponding gas. Therefore a conversion to the actual volume concentration has to be made. In general:

$$\text{Actual cross-sensitivity} = \frac{\text{Table value x volume concentration}}{100} \text{ [Vol.\%]}$$

For the components of the gas mixture the following values result:

C_2H6 : -0.0043% by volume;

CO2 : -0.1080% by volume;

N_2 : 0.0000 Vol. %

Σ = -0.1123% by volume

To determine as accurately as possible the actual total cross sensitivity, a correction factor must be determined, since the sum of the cross sensitivities does not relate to 100% but to 100% minus the oxygen concentration (here 95%).

The correction factor is calculated:

$$\text{Correction factor} = \frac{100}{(100 - O2\ \text{concentration})}$$

This results in the following correction factor:

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

For the gas mixture, the corrected total interference is therefore calculated to a good approximation:

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

The corrected total cross-sensitivity with change of prefix sign can now be used to correct the zero point calibration. In this example the zero point would be adjusted to +0.1182% by volume.

A neglect of the cross sensitivity, in this example, would mean a relative error of about 2%.

NOTICE!

After zero point calibration the measuring range end value must always be calibrated!

12.2 END VALUE CALIBRATION

Before the measuring range end value is calibrated, review of the zero point must always be made.

The procedure during calibration is as follows:

- Set test gas flow rate with a needle valve or flow metre to a maximum. 60 l/h. The volume flow of the calibration gas should always correspond to the gas volume flow;
- Wait approx. 30 seconds until the display has stabilised.
- If necessary, adjust, using the end value potentiometer the O_2 value of the test gas,

  e.g. in the case of air to 20.9% = 7.344 mA in a measuring range 0 - 100% = 4 - 20 mA.

13 CLEANING

NOTICE!

In the event of external contamination, clean the transmitter only with a cloth dampened with soapy water.

14 DECOMMISSIONING

For long-term shutdown, it is recommended to flush the transmitter with a dry, inert gas such nitrogen, to prevent damage to the measuring cell by aggressive and corrosive humid gases.