Embracing Challenge

Oxygen Analyzer Series PMA®

PMA 45K1

Instruction Manual
Version 1.00.01

Dear customer,

Thank you for buying our product. In this instruction manual you will find all necessary information about this M&C product. The information in the instruction manual is fast and easy to find, so you can start using your **M&C** product right after you have read the manual.
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 manual.
For additional information about our products and our company, please go to **M&C**'s website **www.mc-techgroup.com**. There you will find the data sheets and manuals of all our products in German and English.

Version: 1.00.01

Content

List of Illustrations

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1 GENERAL INFORMATION

The product described in this operating manual has been examined before delivery and left our works in perfect condition related to safety regulations. In order to keep this condition and to guarantee a safe operation, it is important to heed the notes and prescriptions made in this operating manual. Furthermore, attention must be paid to appropriate transportation, correct storage, as well as professional installation and maintenance work.
All necessary information a skilled staff will need for appropriate use of this product are given in this operating manual.

2 DECLARATION OF CONFORMITY

CE - Certification

The product described in this operating manual complies with the following EU directives:

RoHS Directive

The requirements of the RoHS2 (‘Restriction of Hazardous Substances 2’) directive 2011/65/EU and its annexes are met.

EMC-Instruction

The requirements of the EU directive 2014/30/EU “Electromagnetic compatibility“ are met.

Low Voltage Directive

The requirement of the EU directive 2014/35/EU “Low Voltage Directive“ are met.
The compliance with this EU directive has been examined according to DIN EN 61010.

Declaration of conformity

The EU Declaration of conformity can be downloaded from the **M&C** homepage or directly requested from **M&C**.

3 SAFETY INSTRUCTIONS

Please take care of the following basic safety procedures when mounting, starting up or operating this equipment:

Read this operating manual 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.

Attention must be paid to the requirements of **VDE 0100** (IEC 364) when setting high-power electrical units with nominal voltages of up to 1000 V, together with the associated standards and stipulations.

Check the details on the type plate to ensure that the equipment is connected to the correct mains voltage.

Protection against touching dangerously high electrical voltages:
Before opening the equipment, it must be switched off and hold no voltages. This also applies to any external control circuits that are connected.

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

The device must not be used in hazardous areas.

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

Installation, maintenance, monitoring and any repairs may only be done by authorized personnel with respect to the relevant stipulations.

4 WARRANTY

If the equipment fails, please contact **M&C** directly or else go via your appointed **M&C** dealer.
We offer a one year warranty as of the day of delivery as per our normal terms and conditions of sale and assuming technically correct operation of the device. Consumables are hereby excluded. The terms of the warranty cover repair at the factory at no cost or the replacement at no cost of the equipment free ex user location. Reshipments must be sent in a sufficient and proper protective packaging.

5 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.

High voltages!
Protect yourself and others against damages which might be caused by high voltages.

6 INTRODUCTION

The manual on hand describes the operating instructions for the stationary oxygen analyzer **PMA 45K1** as applied within the industry.

6.1 SERIAL NUMBER

The type plate with the serial number is on the left side of the of the analyzer housing. Whenever you call **M&C** regarding questions or orders for the spares, please give us the serial number of your **PMA 45K1.**

6.2 POWER SUPPLY

The internal power supply of the oxygen analyzer **PMA 45K1** is 115 V AC or 230 V AC, for 40 Hz up to 60 Hz. Exact indications are made on the type plates. Deviations in the power supply of ±10% have no influence on the proper functioning of the analyzer.

7 APPLICATION

The oxygen analyzer type **PMA 45K1** is suitable for the continuous use in order to determine the oxygen concentration, also in nuclear power engineering installations. Measurements in dry and particle free gases are possible. The inlet dew point of the gas must not exceed +40 °C.

The features of the analyzer are operation reliability, preciseness, stability of the measurement and a small need of maintenance.

The measurement is based on the physical magneto-dynamic measuring principle and is one of the most precise methods to determine the volumetric content of oxygen in the gas phase within the measuring range of 0-100 vol% O_2.

This measuring method shows only very little cross sensitivities vis-à-vis other measuring gas components.

The gas flows directly against the measuring cell which is characterized by a small volume of only 2 cm^3 (small dead volume). Furthermore, the measuring cell stands out due to robustness, extremely low drifts, a fast response time (T_{90} < 5 sec.), high pressure resistance of 16 bar in case of failure as well as a density of smaller than 10^{-6} mbar x l/s (helium leak test).

Variations of the flow rate within a range of 0 Nl/h up to 60 Nl/h air produces a change in the oxygen indication of lower than 0,2 vol% O_2.

The measurements of process gases in nuclear power engineering areas are typical applications of the **PMA 45K1**.

8 TECHNICAL DATA

Oxygen Analyzer Series PMA®	**Version PMA 45K1** heated oxygen analyzer in aluminium cast housing
Part-No.	**05A4060** : **PMA 45 K1,** power supply 230 V 50 Hz **05A4060a** :**PMA 45 K1,** power supply 115 V 60 Hz
Measuring ranges	2 measuring ranges selectable internally: 0-1, 0-2,5, 0-5, 0-10 and 0-25 vol% O_2 linear and position EXTERN
Remote identification of measuring range	Potential free contacts for each selected measuring range, capacity max. 24 V DC, 0.5 A
Combined analogue/digital indication	Digital indication LCD 4 ½ digit, 9 mm high for measuring range 0-100 % O_2, selectivity 0.01% O_2
Measuring range remote change-over	Measuring ranges selectable via external potential-free contacts 30 V DC 3 mA DC
Output signal	0-10 V DC, electrically isolated, load > 100 KΩ for 100 vol% measuring range and 0-20 or 4-20 mA* for selected range, electrically isolated, max. Load 300/500 Ω
Status alarm	For minimum flow alarm, transmitter temperature < 40 °C, light source defective, measuring system defective, failure of tension: LED-indication and contact outlet: change-over contact, potential-free, max. 24 V DC, 0.5 A
Response time for 90% value	< 5 seconds at 60 Nl/h air
Accuracy after calibration	Deviation: analogue signal output = ±1 % of span 2.5 – 25 % / Digital indication = ±0.1 vol% O_2, = ±2 % of span 1%
Reproducibility	Analogue output = < 1 % of span / Digital indication = ± 0.1 vol% O_2
Influence of ambient temperature	No influence up to 50°C
Influence of barometric or outlet pressure	The O_2 indication varies proportionally to the barometric or outlet pressure
Influence of the sample gas quantity	Variation between 0-60Nl/h air will cause a change of indication <0.2 vol% O_2
Sample gas quantity	Max. 60 Nl/h
Flow alarm	Thermal conductivity sensor in measuring cell outlet
Pressure resistance	Operating pressure max. 0.6 bar, accident resistance max. 16 bar
Density	Leak rate < 10^{-6} mbar x l/s with He leak test
Gas volume of the sample gas way	ca. 12 ml
Sample gas temperature	-10 °C up to +50 °C dry gas
O_2 Transmitter temperature	Adjusted at works to 55 °C
Ambient temperature	-10 °C up to +50°C
Storage temperature	-20 °C up to +60 °C, relative humidity 0-90% rF
Power supply	Internal power supply unit available for 230VAC standard or 115 V AC **(a)*** ±10 %, 40-60 Hz, 35.5 VA
Electrical connections	Clamps 2.5 mm^2, 4 x M20 cable gland ø11-13.5 mm (power supply, signals, span position and remote selection, status alarm)
Material of parts in contact with sample gas	Platinum, glass, stainless Steel 1.4571, Epoxy
Sample gas connections	1/4“ NPT i
Protection	IP 54 EN 60529
Applied standards	Electrical safety EN 61010 part 1 8.2002 EMC: Interference emission EN 61000 part 6-3:2007 and EN 61000-6-4:2007, Interference resistance EN 61000 part 6-2:2006
Housing / Colour	Alu cast housing for wall mounting / blue
Dimensions / Weight	356 x 275 x 200 mm / h x w x d / approx. 20 kg
OPTIONS EN for exchange of outdated instruments	**1.:** 2 connecting pipes 1/8“, 500 mm long and 2 tube fittings – straight connection
	2.: Adaption mounting plate with fastening material

* Please specify with your order.

9 DESCRIPTION

The core of the **PMA 45K1** is the patented magneto dynamic oxygen measuring cell. The measuring principle is one of the most precise methods for the volumetric determination of the oxygen content in the measuring range of 0-100 vol% O_2.

The oxygen analyzer **PMA 45K1** is designed for the stationary use and can also be applied in nuclear installations. The characteristics of this analyzer are overpressure security up to 16 bar as well as a guaranteed leak tightness with a leak rate of less than 10^{-6} mbar x l/s.
The transmitter is set to a temperature of +55 °C. The temperature regulator is constructed such as the low voltage device and the 115/230 V power part are separated via an opto-isolator with no voltage switch.
A non-reversible overpressure fuse avoids that the transmitter is overheated above 72 °C.
The great surface heating elements mounted on the transmitter surface guarantee a quick and constant temperature circulation.
In order to ameliorate the heat storage and isolation, the transmitter is equipped with an insulation cover.

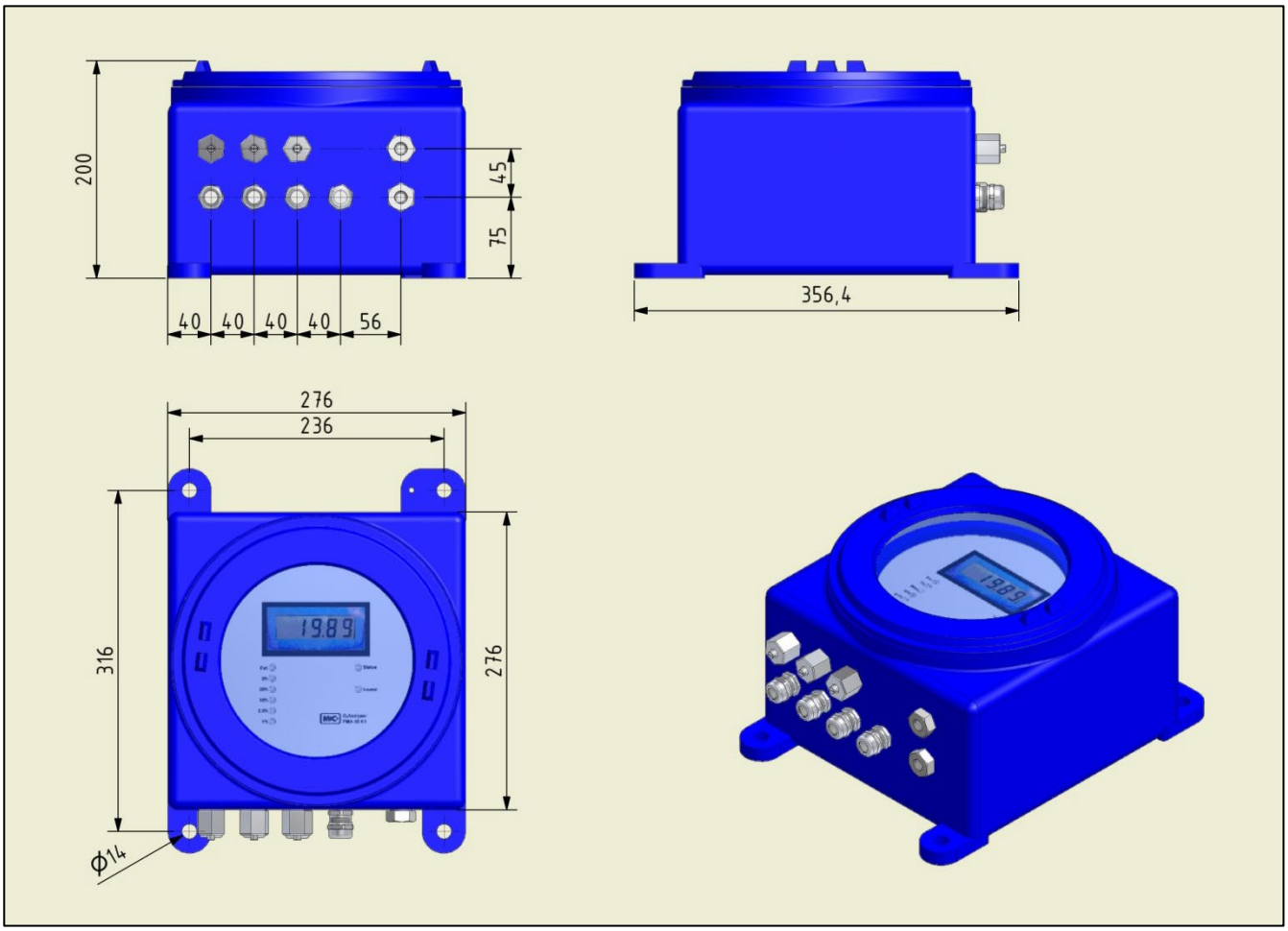


Figure 1 Dimensions of oxygen analyzer PMA 45K1

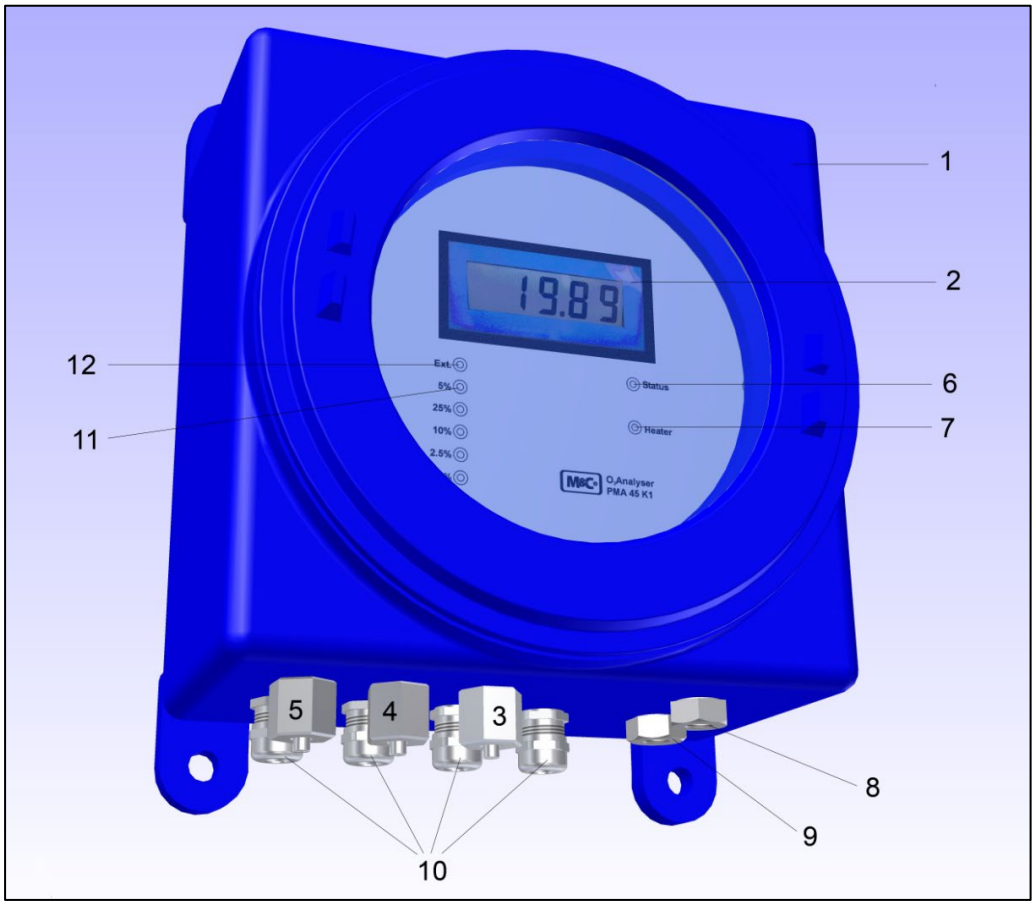


Figure 2 PMA 45K1

An inspection window in the housing **1** of the analyzer makes it possible to control the measuring value display **2**, the LEDs **6** (status alarm) and **7** (heating regulation) as well as the span LEDs **11** and **12**.

All operating devices are accessible from outside and guarantee a simple and user-friendly handling for calibration as well as for the measuring range switch over.
The operating devices are:

- Adjustment of measuring range final value **3**,
- Measuring range selector switch **4** and
- Adjustment zero point **5**.

The oxygen indication of the **PMA 45K1** is made by a digital display instrument **2**. Here, the oxygen value is shown within a range of 0-100.00 vol% with a definition of 0.01 vol%.
The measuring range switch over is made via the selector switch **4**. The selected measuring range is indicated via a respective LED **11** on the front plate of the **PMA 45K1**.
The selection of the measuring range can also be effected externally. The LED **12** on the front plate of the analyzer in connection with the respective measuring range LED is signalizing the external measuring range control.

The function of the analyzer heating is indicated with LED **7**. When switching on the instrument, this LED is permanently illuminated in yellow. When the LED is flashing, the operating temperature is achieved, when the LED is out, the temperature is exceeded. For all other status alarms as described below, the LED **6** changes from green to read.

The standard **PMA 45K1** is equipped with a collective alarm output. This is a potential-free changeover contact in “safety-first position”. The capacity is 110 mA at 24 V. The following status indications are signalized:

Light source defective,
Measuring cell uncoupled,
Flow alarm <10 / >70 Nl/h ,
Error control of power supply unit,
Power supply failure,
Temperature Transmitter <+45 °C / >+60 °C,
Fault measuring range selection.

Power supply, mV- or mA-output, remote measuring range selector as well as alarm output are effected via the cable inlets **10** on the lower side of the analyzer housing.

Sample gas inlet **8** and outlet **9** with ¼“ NPT i thread are also placed on the bottom side of the housing.

10 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 3 shows the diagram of the measuring cell as well as the optical system for the detection of the dumbbell’s movement.

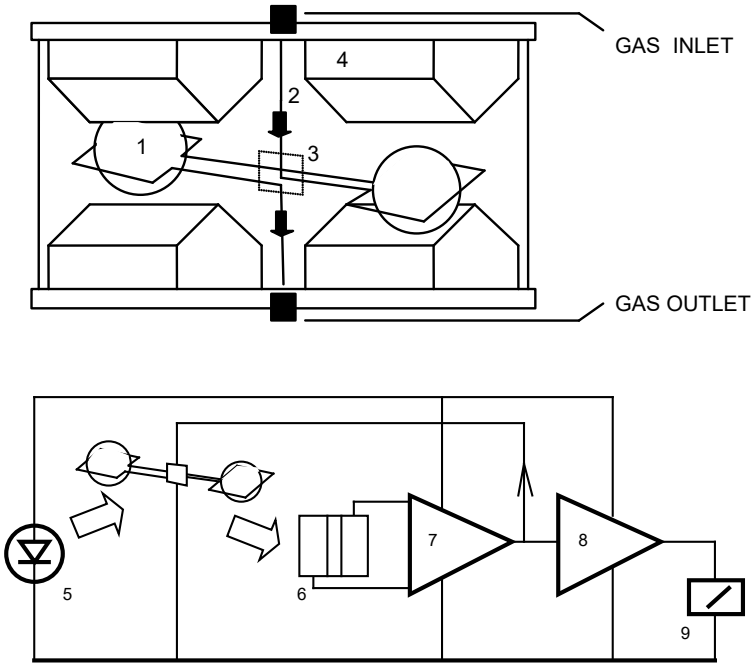


Figure 3 Diagram of the measuring cell and optical signal processing

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.

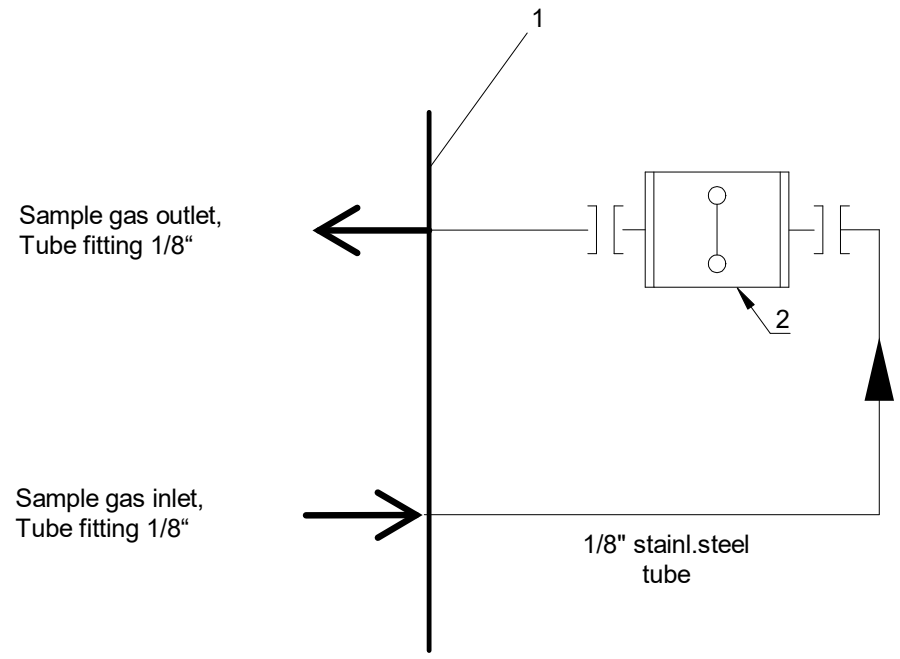
In case the dumbbell is pushed out of the magnetic field, the tension of the photoelectric cell is immediately changed. The measuring amplifiers ⑦ and ⑧ are producing a respective current which develops via the wire coil on the dumbbell an electro-magnetic load moment. The load moment is resetting the dumbbell into its zero position.

Every change of the oxygen concentration produces a linear 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.

11 GAS FLOW CHART

Figure 3 shows the gas flow chart of the oxygen analyzer **PMA 45K1**.



1 Analyser housing
2 Measuring cell

Figure 4 Gas flow chart

The sample gas arrives in the measuring cell **2** via the inlet fitting.

It is very important to protect the measuring cell **2** against liquid and dust particles. This is the reason why the externally mounted upstream gas conditioning system must be equipped with a fine filter of at least 2 micron porosity (e.g. type **FP-2T**).
The gas volume flow of 6 Nl/h up to 60 Nl/h is adjusted via an externally mounted flowmeter with needle valve.

12 RECEIPT OF GOODS

The analyzer **PMA 45K1** is a completely pre-installed unit.

- Please take the analyzer and possible special accessories carefully out of the packaging material immediately after arrival, and compare the goods with the items listed on the packing list;
- Check the goods for any damage caused during delivery and, if necessary, notify your transport insurance company without delay of any damage discovered.

The oxygen analyzer must be stored in a weather - protected and frost-proof area !

13 INSTALLATION

The analyzer **PMA 45K1** is constructed for stationary wall mounting. All electrical connections are to be found inside the analyzer housing.

The correct installation as well as an optimal sample gas conditioning unit mounted upstream – if necessary with an appropriate gas sample probe – guarantee a long lasting functioning and a minimum of maintenance.

In case of outdoor operation, the analyzer must be protected against sun, wind and rain.
At the installation location constant climatic ambient conditions (pressure, temperature) are necessary to prevent a falsification of the measurement due to changing barometric pressure. Further, there is the risk of condensation in case the ambient temperature falls below the dew point temperature of the sample gas in front of the measuring cell.
A vibration-free location is ideal for mounting; if this is not possible, rubber-bonded metals (anti-vibration) have to be mounted in order to decouple the housing. The analyzer must not be installed in direct proximity of heat sources.

The sample gas must be dry and free of dust to avoid contaminations and a falling below the dew point inside the analyzer. In principle, a fine filter with a porosity of minimum 2 micron should be installed upstream.

Counter pressure in the sample gas outlet should be avoided!

14 POWER SUPPLY CONNECTIONS

14.1 SAMPLE GAS INLET AND OUTLET

Sample gas inlet and outlet (**8**, see figure 2) are placed on the lower side of the analyzer. These are 1/4“ NPT i threads.

NOTE!

When fastening the screw connection, hold up at the back side with a respective spanner!

It is recommended to make a leak test afterwards.

The sample gas must be dry and free of dust, and the sample gas inlet temperature should not exceed +50 °C. If this is not the case, a gas cooler with automatic condensate evacuation must be mounted upwards.

The sample gas outlet should have atmospheric pressure if possible because a pressure increase inside the measuring cell will falsify the oxygen indication. The maximum inlet pressure is 600 mbar.

The sample gas quantity should be adjusted according to the requirements between 6 Nl/h and 60 Nl/h air (external flowmeter).

14.2 ELECTRICAL CONNECTION

WARNING!

False supply voltage can damage the equipment. When connecting the equipment, please ensure that the supply voltage is identical with the information provided on the model type plate!

Take care that the instrument hat got a sufficient connection to earth!

NOTE!

Attention must be paid to the requirements of IEC 364 (DIN VDE 0100) when setting high-power electrical units with nominal voltages of up to 1000V, together with the associated standards and stipulations!

A main switch and a respective fuse must be provided externally by the client.

After removing the window cover, the electrical connections are freely accessible.

- In order to remove the window cover, unscrew the safety screw (hexagon socket screw) with a hexagon key 2.5 mm;
- Unscrew the window cover by turning it counter-clockwise with the help of a flat iron with the dimensions 10 x 10 x 300 mm (H x L x L);
- Unscrew the fixing screws on the front plate and remove the front plate carefully (take care of the connecting cables of the front plate).

The electrical connections are to be made according to figure 5.

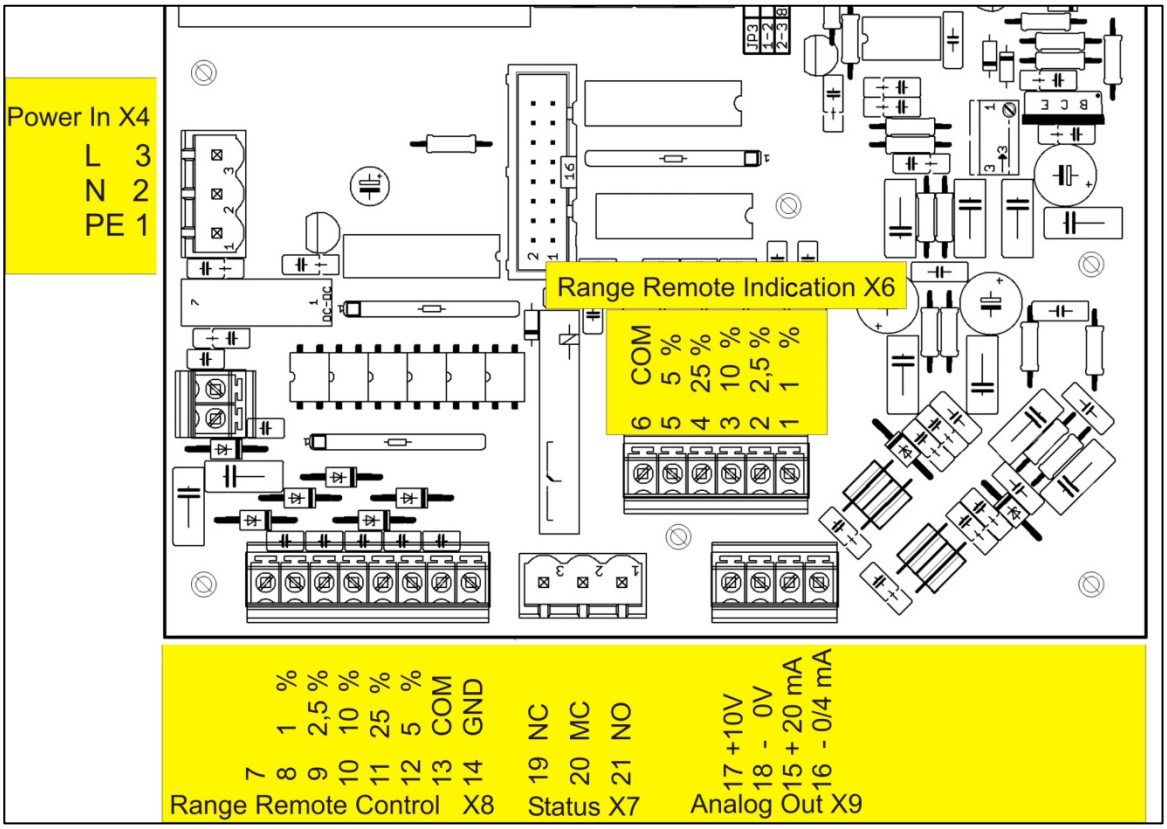


Figure 5 Electrical connections PMA 45K1

14.3 DETERMINATION OF THE TWO MEASURING RANGES TO BE SELECTED ON THE INSTRUMENT

In order to minimize operating errors, the **PMA45K1** provides the possibility to determine two measuring ranges that may then be selected via a switch on the instrument.
The selection of measuring range 1 and 2 is made via two jumpers on the below illustrated plate. On the photo, you can see that for range 1 the 1 % measuring range has been selected and for range 2 the 2.5 % measuring range. The selected measuring ranges refer only to the mA-outlet. The digital indication is always in the 100.00 vol% O_2 measuring range.
Via the external measuring range selection, all measuring ranges are available.

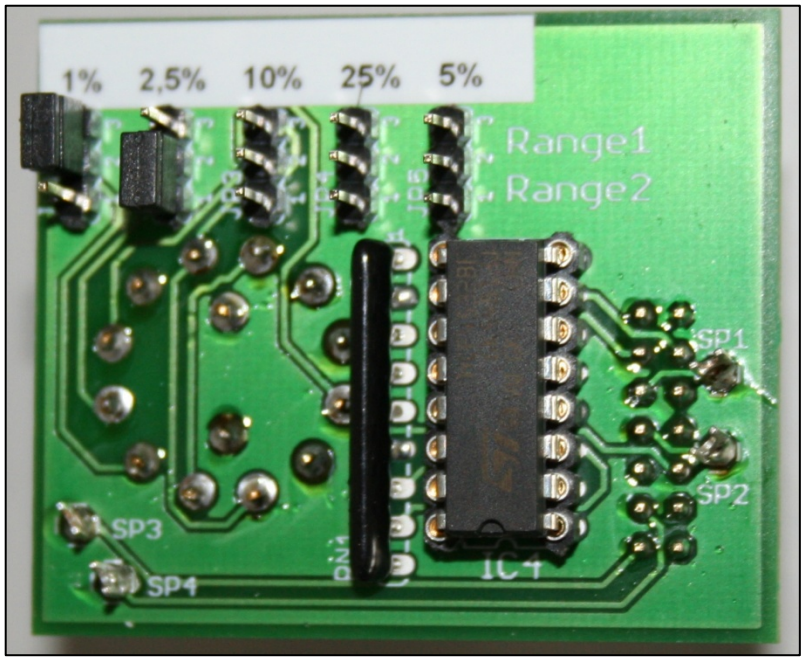


Figure 6 Determination of measuring range via jumpers

15 STARTING UP

The following steps have to be done when starting up the analyzer:

- Before switching on the main switch, check whether the electrical connections and the gas connections have been executed correctly. The tension as indicated on the type plate must correspond to the power supply.

- When switching on, the display of the analyzer shows an oxygen value < 21 vol% due to the ambient air inside the measuring cell;

- The warming up time of the analyzer is indicated by the permanently illuminated temperature control LED on the front plate (**7**, see figure 2). After approximately 30 minutes, the **PMA 45K1** has achieved its transmitter temperature. This is signalized by the twinkling of the temperature control LED.

NOTE !

A stable temperature, however, is only achieved after appr. 3 hours, and the analyzer can then be calibrated according to the following instructions. In order to control the stable status, it is recommended to execute a further calibration after 24 hours!

16 CALIBRATION

The preciseness of an analyzer depends to an important extent on its calibration.

NOTE!

Before executing a calibration, it must be assured that the calibration conditions correspond to the conditions during the measurements. The flow quantity and the barometric pressure conditions must be constant. Under these conditions, a calibration of the analyzer becomes necessary nearly once a week in order to keep the exactness. Should there, however, be a considerable change of the flow quantity or the barometric pressure conditions, a new calibration is necessary.
During the calibration, the instrument must not be exposed to any vibrations.

For the zero point calibration of the analyzer, an oxygen-free gas – in most times nitrogen (N_2 5.0) is used as zero gas.
Regarding the sensitivity adjustment, no special test gas mixtures are necessary due to the measuring principle and the linearly measuring ranges of the **M&C** O_2 analyzers. Dry and clean air is sufficient. For measuring value concentrations of > 40 % O_2, it may be recommendable to make a calibration with a respective test gas.

16.1 ZERO POINT ADJUSTMENT

- Connect a flexible PVC or Viton tube with the pressure reducer of the N_2 zero gas bottle. The pressure reducer should have got an output range of adjustment of max. 0 – 1.5 bar.
- Open the cylinder valve first and then open the closed output valve of the pressure controller. Purge the pressure controller including the tubes for approx. 5 seconds.
- Check the adjusted pressure and reduce it if necessary to ≤ 0.1 bar, then close the output valve of the pressure controller again.
- Connect the free tube end of the zero gas bottle connection to the gas inlet of the analyzer or – if existing – to the external calibration valve.
- Open slowly the pressure controller output valve in order to avoid pressure peaks.
- Adjust the flow at approx. 50 l/h on the flowmeter.

NOTE!

Always calibrate with the same gas quantity that is taken for measurement.

- Wait approx. 20 - 30 seconds until the indication is stable.
- Turn the measuring range selector switch (**4**, see figure 2) in position 2.5 %.
- If necessary, adjust the zero point with a screw driver to exactly 0 % O_2 on the zero point potentiometer (**5**, see figure 2) on the bottom side of the housing.
- Check the signals of the recorder output at 0.0% O_2 :

Recorder output signal	Measured value
0-10 V	0 V
0-20 mA	0 mA
4-20 mA	4 mA

NOTE!

When analysing a gas mixture, the single components have to be checked whether there are cross sensitivities, and these have to be considered during the zero point calibration (see chapter 16.1.1 and 16.1.2).

- Close the pressure controller output valve and the cylinder valve.
- Remove the tube connection from the analyzer.
- The zero point calibration is finished.

NOTE!

After the zero point calibration, also the final value has to be calibrated again.

16.1.1 CROSS SENSITIVITIES

The following list shows the cross sensitivities of the most important gases at 20 °C and 50 °C. All values refer to a zero point calibration with N_2 and a final value calibration with 100 vol% O_2. The deviations apply for 100 vol% each of the respective gases.

Gas	Elemental Formula	20°C	50°C
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
Isobutylene	C_4H_7	- 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
Ethan	C_2H_4	- 0.43	- 0.47
Ethyl benzene	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 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	- 0.27	- 0.31
Methylen chloride	CH_2Cl_2	- 1.00	- 1.10
Methyl propylene	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**
Sulphur dioxide	SO_2	- 0.18	- 0.20
Sulphur fluoride	SF_6	- 0.98	- 1.05
Hydro silicone	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	CH_3F	- 0.49	- 0.54
Water (vapour)	H_2O	- 0.03	- 0.03
Hydrogen	H_2	+ 0.23	+ 0.26
Xenon	Xe	- 0.95	- 1.02

16.1.2 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 (N_2) for the zero calibration.

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

1 vol% C_2H_6 (Ethan);
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:

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

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:

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

The correction factor is the following:

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

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 the zero point has to be adjusted at +0.1182 Vol.%.

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

NOTE! **After the zero point calibration the span final value has to be calibrated too!**

16.2 SENSITIVITY ADJUSTMENT

Before doing the sensitivity calibration, a zero point calibration must have been completed.

- Place the span selector switch to the measuring range in which the sensitivity calibration shall be effected. It is recommended to make a calibration with dry and clean air in the range of 25%. Place selector switch (**4**, see figure 2).
- Connect a flexible PVC or Viton tube with ambient air or instrumental air or if applicable with a pressure reducer of the test gas bottle. The pressure reducer shall have an output range of adjustment of max. 0 - 1.5 bar.
- Open the bottle or the instrumental air valve and afterwards open the closed pressure reducer output valve and purge the pressure controller including the flexible tubing for approx. 5 seconds.
- Check the adjusted regulating pressure and if necessary reduce it to ≤ 0.1bar, then shut the pressure regulator output valve again.
- Connect the free tube end of the instrumental air connection or of the test gas bottle connection to the gas inlet of the analyzer.
- Open slowly the output valve of the pressure regulator to avoid pressure peaks.
- Adjust the gas flow to approx. 50 l/h on the flowmeter.

NOTE!

Always calibrate with the gas quantity that is used for measurement.

- Wait approx. 20 - 30 seconds, until the indication is stable.
- If necessary, adjust in the front of the sensitivity potentiometer (**3**, see figure 2) by means of the screw driver the sensitivity to the value that corresponds exactly to the test gas concentration. For air this is for example 20.9 % O_2.
- Check the recorder's output signals at 20.9% O_2 :

Output signal	**Measured value range 100 % O_2**	**Measured value range 25 % O_2**
0-10 V	2.09 V	
0-20 mA		16.744 mA
4-20 mA		17.40 mA

- Shut off pressure reducer valve and bottle- resp. instrumental air valve respectively switch of the integrated sample gas pump.
- Remove the tube connection on the analyzer.

Determination of the signal value:

$$\frac{(S_e - S_{np})\ \text{V or mA} \times \text{gas concentration Vol. \% } O_2}{\text{Measuring range final value Vol. \% } O_2} + S_{np}$$

Se = Final value signal output
Snp = Zero point signal output

- Shut the pressure regulator output valve and the bottle valve. Remove the tube connection on the analyzer.

The sensitivity calibration is finished.

NOTE!

If during the sensitivity calibration great deviations have to be compensated (>2% O_2) at the potentiometers, a second zero and sensitivity calibration is recommended.

ATTENTION

After finishing the calibration, turn selector switch to the desired measuring range again.
The mA output signal is dependent on the measuring range!

17 MEASURING

For the first starting up at a new location, all before mentioned steps have to be performed.
The requirements of precision determine the interval of the new calibration. After having selected the desired measuring range, the analyzer is ready for measurement.

NOTE!

The sample gas must be free from all liquid or solid particles, i.e. the dew point of the gas has to be below the ambient or instrument temperature so that no condensate will occur inside the instrument. If necessary, lower the dew point by means of a cooler or dryer. For dust filtration, use a filter with 2 micron porosity!

We will be pleased to inform you about an optimal gas conditioning!

18 CLOSING DOWN

In case the installation to be controlled is shut down for a short period, the analyzer should stay on stand-by. Not further actions are required.

In case of a long term closing down, it is recommended to purge the analyzer with dry and clean inert gas (e.g. ambient air) in order to avoid a damage of the measuring cell due to aggressive or corrosive humid gases.

19 STORAGE

NOTE!

The storage of the analyzer should be effected in a protected frost-free room!

20 MAINTENANCE

Before executing the maintenance works, the specific security measurements relating to the installation and the process have to be observed!

WARNING!

Dangerous tension. Before executing the maintenance works, the analyzer and all external electrical circuits in connection with the analyzer have to be switched off from tension.

For use in explosive areas, the EX directives have imperatively to be observed!

NOTE!

It is important to use only the original spare parts that correspond to the M&C specification!

Thanks to the physical measuring principle and the construction of the analyzer, no intensive and complex maintenance works are required. The preceding components of the sample gas conditioning unit are to be maintained according to the respective operating manuals.

The calibration of zero point and measuring range final value are to be executed with the respective test gases according to description.

21 ANNEXE

Further product information is available on our internet catalogue:
www.mc-techgroup.com