Embracing Challenge

Oxygen – Analyzer Series PMA®

PMA20

Instruction Manual
Version 1.01.00

Dear customer,

Thank you for buying our product. In this manual you will find all necessary information about this M&C product. The information in the 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 our products in German and English.

With the release of this version all older manual versions will no longer be valid. The German instruction manual is the original instruction manual. In case of arbitration only the German wording shall be valid and binding.

PMA® is a registered trade mark.

Version: 1.01.00

Content

List of Illustrations

HEAD OFFICE

M&C TechGroup Germany GmbH ◆ Rehhecke 79 ◆ 40885 Ratingen ◆ Germany
Telephone: 02102 / 935 – 0
Fax: 02102 / 935 – 111
E - mail: info@mc-techgroup.com
www.mc-techgroup.com

1 General information

The product described in this manual 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 manual need to be followed. This manual includes all information regarding proper transportation, storage, installation, operation and maintenance of this product by qualified personnel.
Please follow all instructions and warnings closely.
Please read this manual 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 Declaration of conformity

CE - Certification

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

EMV-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

Follow these safety directions and instructions regarding installation, commissioning and operation of this device:

Read this manual before commissioning and operating the product. Please make sure to follow all safety instructions.

Installation and commissioning of electrical devices must be carried out only by qualified skilled personnel in compliance with the current regulations.

The installation and commissioning of the device must conform to the requirements of VDE 0100 (IEC 364) 'Regulations on the Installation of Power Circuits with Nominal Voltages below 1000 V' and must be in compliance with all relevant regulations and standards.

Before connecting the device, please make sure to compare the supply voltage with the specified voltage on the product label.

Protection against damages caused by high voltages:

Disconnect power supply before opening the device for access. Make sure that all extern power supplies are disconnected.

Operate the device only in the permitted temperature and pressure ranges. For details please refer to the technical data sheet or manual.

Install the device only in protected areas, sheltered from rain, sun and moisture. The product should not be exposure to the elements.

This device is NOT certified to be installed or operated in explosive 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.

3.1 Intended use

The **PMA20** gas analyzer is intended for use in general purpose areas (non-hazardous environments). It may only be operated in compliance with the information in chapter "8 Technical data". Only use the device within the permitted temperature and pressure ranges.

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 instruction manual.

4 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.

5 Used terms and signal indications

Danger

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

Warning

This means that death, severe physical injuries and/or important material damage **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 instruction manual which require user's attention.

Qualified personnel

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.

Toxic!
Acute toxicity (oral, dermal, inhalation)! Toxic when in contact with skin, swallowed or inhaled.

Corrosive!
These substances destroy living tissue and equipment upon contact.
Do not breathe vapors; avoid contact with skin and eyes.

Hot surface!
Contact may cause burn! Do not touch!

Wear protective gloves!
Working with chemicals, sharp objects or extremely high temperatures requires wearing protective gloves.

Wear safety glasses!
Protect your eyes while working with chemicals or sharp objects. Wear safety glasses to avoid getting something in your eyes.

Wear protective clothes!
Working with chemicals, sharp objects or extremely high temperatures requires wearing protective clothes.

Wear safety footwear!

Use safety helmet and full protective goggles!

6 Introduction

The **M&C** oxygen analyzer **PMA20** is a temperature controlled instrument which has been designed for continuous measurements of oxygen concentrations in particlefree and dry sample gas.

6.1 Serial number

The type plate with the serial number is in the lid of the analyzer.
Whenever you call **M&C** regarding questions or orders for the spares please give us the serial number of your **PMA20.**

7 Application

Due to the extremely fast response time of the patented **M&C** magneto-dynamic measuring cell with no stagnant volume as well as the negligible cross sensitivity from other sample gas components, the **M&C** oxygen analyzer **PMA20** has a wide variety of applications. The analyzer is a suitable and reliable instrument for monitoring oxygen concentrations in various gas analytical control applications including flue gas-, inert gas-, ambient air-, fermentation processes- and process or laboratory control measurements.

8 Technical data

Oxygen analyzer Series PMA®	**Version PMA20**
Part No.	02A1000 = 230 V 50 Hz, 02A1000a = 115 V 60 Hz
Measuring ranges	selectable for 0-3, 0-10, 0-30 and 0-100 vol% O_2, linear
Indication	Analoge meter with a scale of 0-30 and 0-100 % for each selected range Analoge meter with a scale of 0-30 and 0-100 % for each selected range, digital meter, 3 1/2 digit 9 mm high for 0-100 % O_2 reading, selectivity 0.1 vol% O_2
Output signal	0-1 V DC non-isolated, load > 100 kΩ, for the range of 100 vol%, and 0-20 mA or 4-20 mA* for the chosen range, non-isolated, max. load 300 Ω
Response time for 90% FSD	< 3 seconds at 60 Nl/h air
Accuracy after calibration	Deviation: analogue = ±1 % of span / digital = ±0.1 vol% O_2
Reproducibility deviation	Analoge = < 1 % of span / digital = ±0.1 vol% O_2
Influence of ambient temperature	No influence up to 45 °C
Influence of barometric pressure	The oxygen reading varies in direct proportion to changes of the barometric pressure.
Influence of sample gas flow	Variation in gas flow between 0-60 Nl/h air will cause a difference of < 0.1 vol% O_2 .
Sample gas inlet pressure	0.01 up to 1 bar g, (PMA20 required admission pressure for competent flow rate, no pump inside)
Sample gas outlet pressure	Outlet of analyzer must discharge freely into atmosphere.
Flow rate of sample gas	Max. 60 Nl/h air, adjustable with needle valve on the flowmeter 7-70 Nl/h
Temperature of sample gas	-10 up to +40 °C, dry gas

Oxygen analyzer Series PMA®	**Version PMA20**
Analyzer temperature	Fixed at +50 °C
Ambient temperature	-10 up to +45 °C
Storage temperature	-20 up to +60 °C, relative humidity 0-90 % RH
Power supply	Internal power unit for 230 V AC standard or 115 V AC available (a)* ±10 %, 40-60 Hz, 26.5 VA
Electrical connections	Terminals 2.5 mm^2; cable gland for power connection: 1 x M 20, cable gland for signal connection: 1 x M 16
Materials in contact with sample gas	Platinum, Glass, Polypropylene, Stainless Steel 316, FKM, Epoxy resin
Sample gas connection	PP hose connectors DN 4/6 for 4 mm ID and 6 mm OD tube
Protection/electrical standard	IP53 EN 60529/EN 61010
Housing/colour	Plastic wall mounting housing/ blue/grey
Dimension (H x W x D)	220 x 214 x 182 mm
Weight	Approx. 3 kg
Options	
02A9015	Option: PMA20 as solvent-resistant version with special measuring cell type PMC-1LB, material: O-ring: Kalrez®, flow meter: PVDF, tubing and fittings: PVDF/SS 316
02A9005	Option: PMA20/30 as chlorine-resistant version with a special measuring cell type PMC-1CL2, gas paths in PTFE/PVDF hose and with purge gas connections
02A9010	Option: certificate according to the German DIN standard EN 14181 or the 13th and 17th Federal Immission Protection Directive (BImSchV) respectively and the Technical Instructions on Air Quality Control (TA-Luft) for analyzer type PMA20
02A9000	Option: PMA with combined analog/digital display. Analog meter with a scale of 0-30 and 0-100 % for each selected range, digital meter, 3 1/2 digit 9 mm high LCD-indicator for 0-100 % O_2 reading, selectivity 0,1 vol% O_2 or digital meter 3 1/2 digit 18 mm high LCD for 0-100 % O_2 reading, selectivity 0.1 vol% O_2

* Please specify with order.

Please note: Nl/h and Nl/min refer to the German standard DIN 1343 and are based on these standard conditions: 0 °C [32 °F], 1013 mbar.

9 Description

The **PMA20** is a reliable and easy-to-operate instrument. It is built into a compact wall mounting housing. The transducer unit maintains a constant operating temperature of 50 °C and a flashing LED on the control panel indicates the proper operating temperature of the analyzer. The four measuring ranges are displayed on the analogue meter with 30/ 100% scale. Two output signals are available. Sample gas connections as well as connectors for incoming power supply and output signals are located inside the terminal box of the housing. The sample gas enters the analyzer via an external protective fine-filter. The required flow rate can be adjusted at the flowmeter with needle valve, mounted on the front panel upstream the **M&C** measuring cell. The internal tubing is made of FKM and PP. Option: "TÜV certificate" or chlorine resistant version.

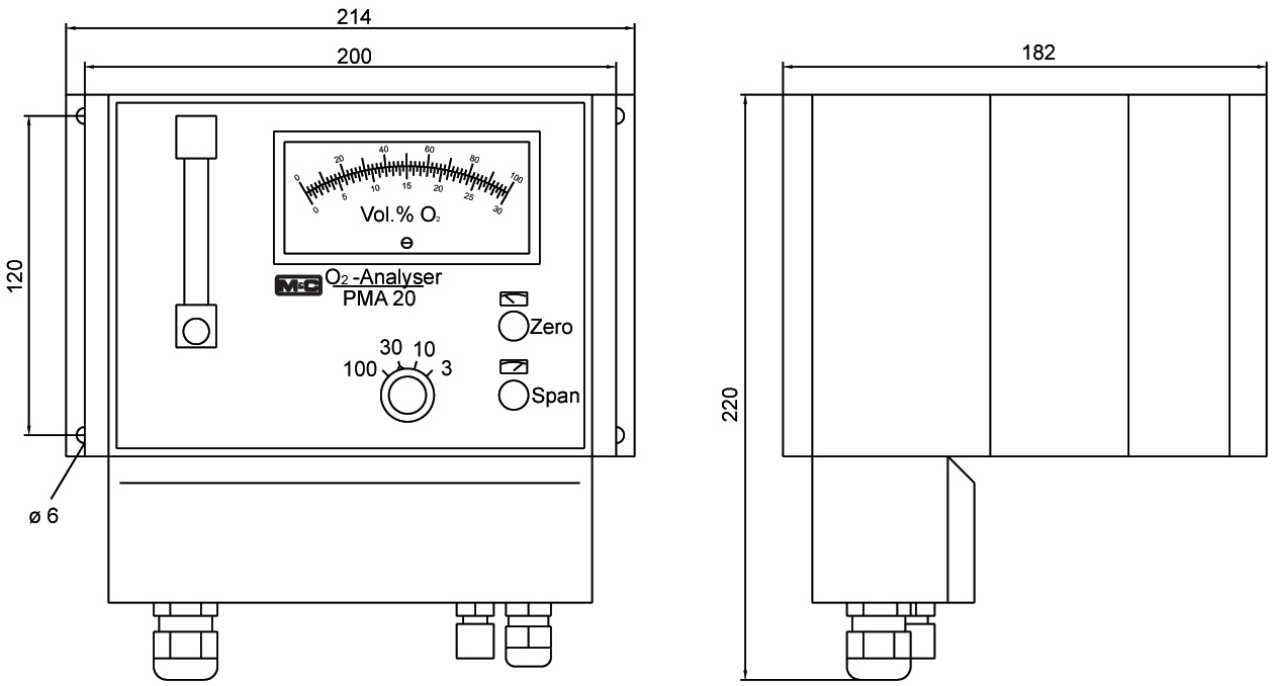
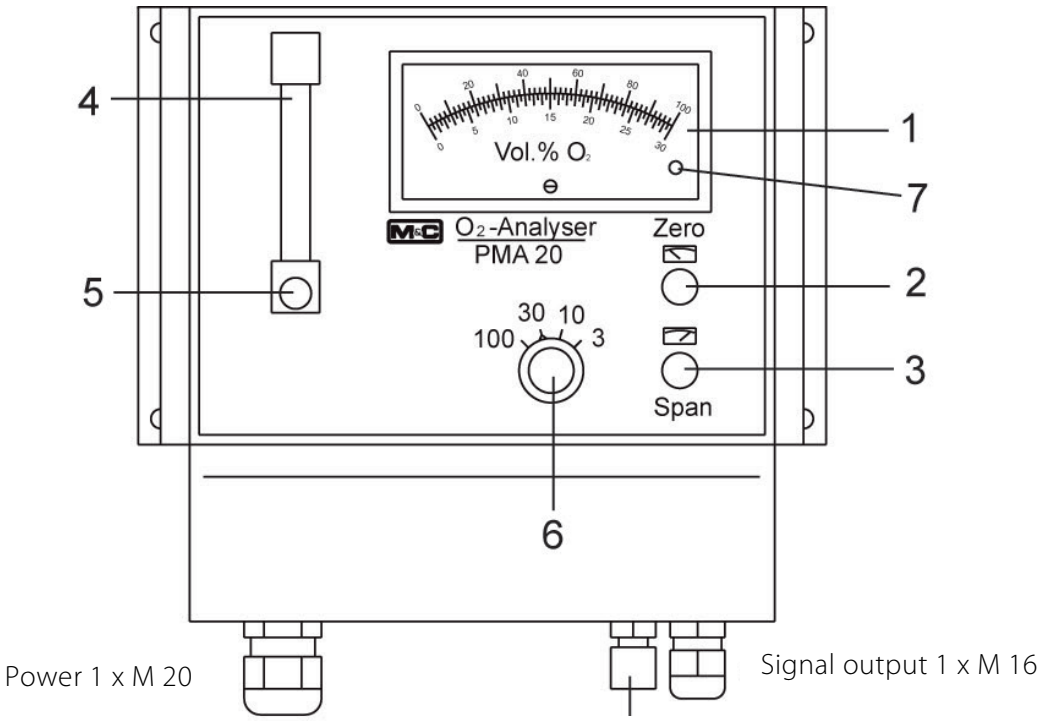


Figure 1 **Dimensions PMA20**

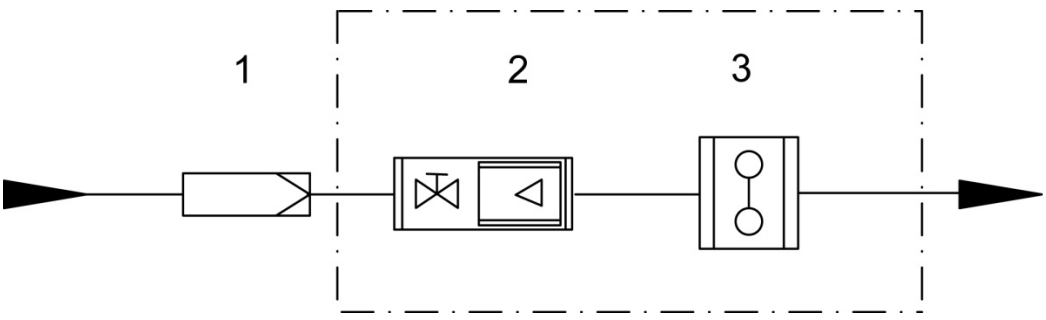
9.1 Front panel



1 Analog indication
2 Zero potentiometer
3 Span potentiometer
4 Flow meter
5 Needle valve 7-70 Nl/h
6 Measuring range selector switch
7 LED - heating control

Figure 2 **Front panel PMA20**

9.2 Gas flow diagram of the analyzer PMA20



1 External fine filter
2 Flow meter with needle valve
3 Measuring cell

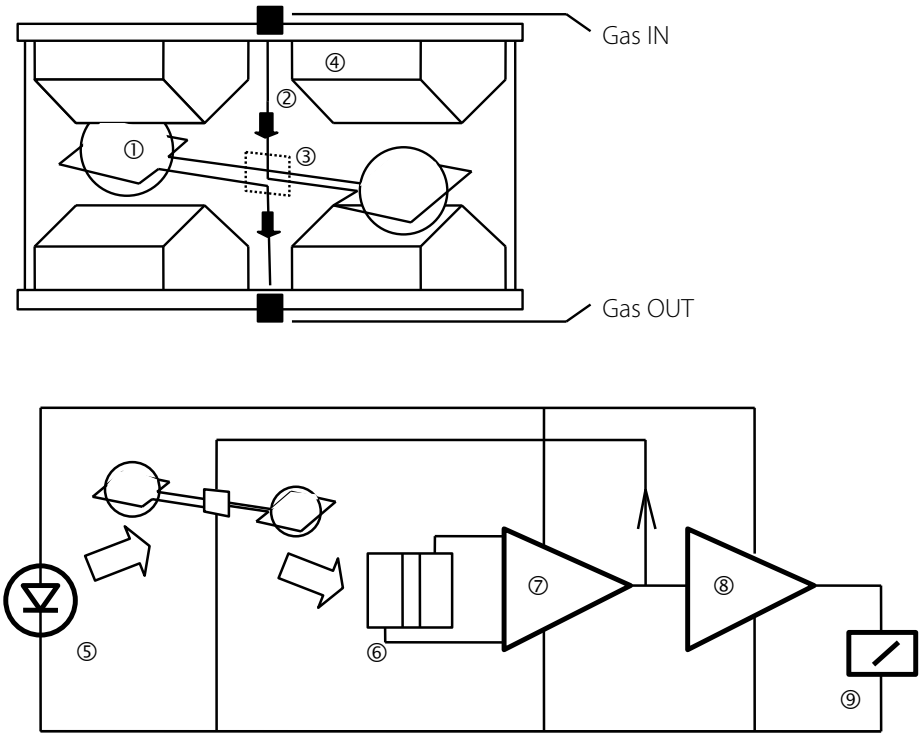
Figure 3 **Gas flow diagram PMA20**

10 The 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 2 shows the diagram of the measuring cell as well as the optical system for the detection of the dumbbell's movement.



① Nitrogen-filled spheres ② Tightening strap out of platinum ③ Mirror
④ Pole pieces ⑤ Projection LED ⑥ Photoelectric cell
⑦ Measuring amplifier ⑧ Measuring amplifier ⑨ Display

Figure 4 Scheme 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 srewed up with two pole pieces ④.

Two permanent magnets are producing an inhomogeneous magnetic field. When oxygen is flowing in, the molecues 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 sheres 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 fieild, 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.

11 Receipt of goods and storage

The analyzer **PMA20** 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.

Note

The oxygen analyzer PMA20 must be stored in a wheather - protected and frost-proof area!

12 Installation

The **PMA20** is intended for stationary operation. In combination with a gas conditioning according to the requirements a long lasting operability and a minimum of maintenance is guaranteed.

Caution

The sample gas has to be dust free and dry to prevent a contamination and condensation in the analyzer.

Basically always connect a fine filter (e.g. type FP-2T, Part No. 01F1200) upstream.

Caution

In case of outdoor operation protect the analyzer against sun, wind and rain. At the installation location constant climatic ambient conditions (pressure, temperature) are necessary to prevent a distortion of the measurement and a condensation in the measuring cell in case the ambient temperature is falling below the dew point temperature of the sample gas.
A vibration-free location is ideal for mounting; if this is not possible, appropriate measures have to be taken. The analyzer must not be installed in direct proximity of heat sources.
The position of operation is not necessarily horizontal.

Danger

The analyzer is allowed to be operated only in non-hazardous areas and with non-ignitiable gases and gas mixtures.

Mounting is done at the four exterior fixing holes (6 mm) with adequate screws. Leave enough space (approx. 120 mm) at the right side of the housing for opening the housing in case of maintenance.

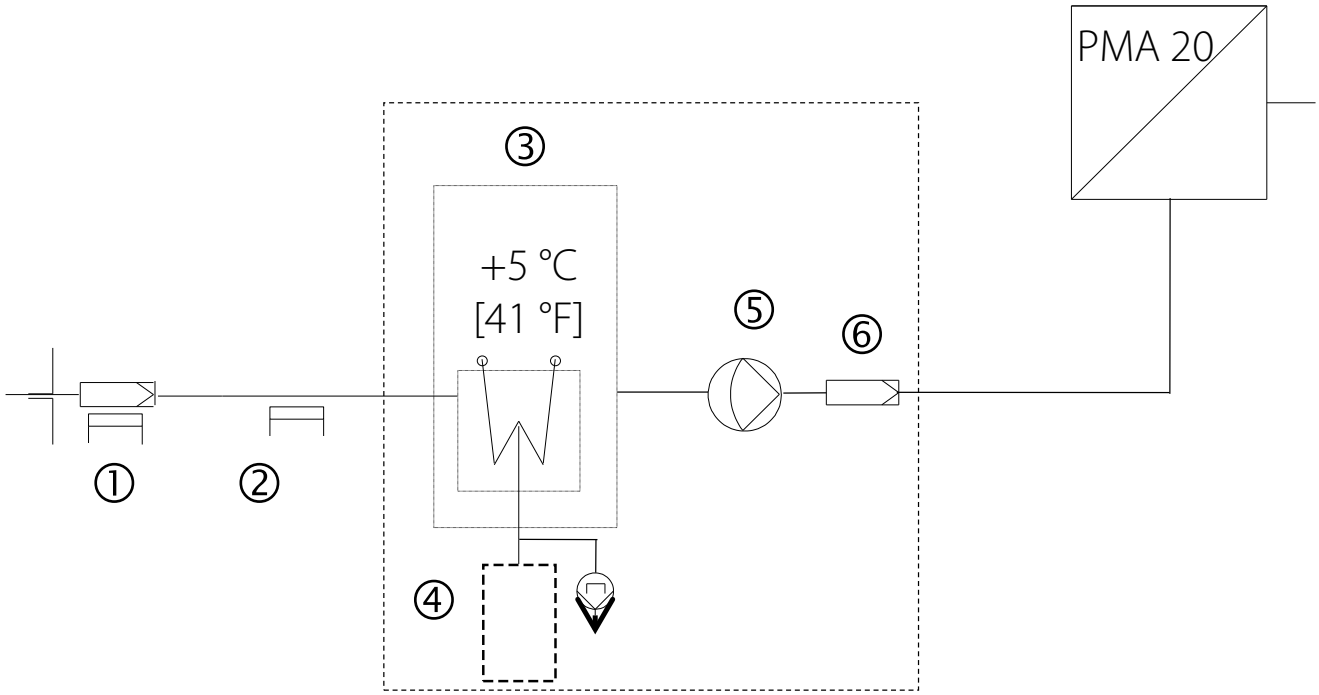
12.1 Connection of Sample gas inlet and sample gas outlet

The sample gas inlet and outlet are placed at the bottom side of the analyzer and have tube connections DN 4/6 mm.

- Connect the sample gas inlet (rear connection) with a corresponding gas conditioning with e.g. a PTFE hose DN 4/6.

Attention Avoid back pressure in the sample gas outlet because an increase of pressure will distort the oxygen indication.
Do not bend the connection hoses.

13 Standard gas conditioning system



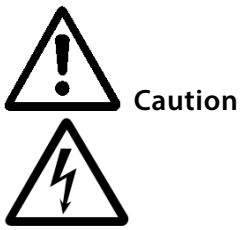
① Heated gas sample probe (e.g. probe SP2000-H)
② Heated gas sample line (e.g. 4M4/6)
③ Sample gas cooler (e.g. ECM-1G)
④ Peristaltic pump or condensate collecting vessel (e.g. SR25.2 or TG-1)
⑤ Diaphragm pump (e.g. N3)
⑥ Fine filter (FP-2T)

Figure 5 **Standard gas conditioning system**

14 Electrical connection

The electrical connection is done at the terminals in the connection box below the analyzer:

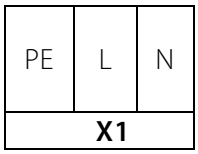
- Loosen the two screws of the lid end remove it.



Caution

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!

Power



Signal output

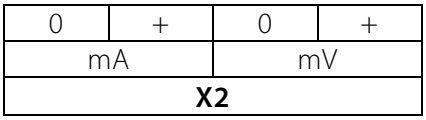


Figure 6 Electrical connection PMA20

- Lead power cable with wire cross section 2,5mm² through the left cable gland with clamping range 8-12 mm cable diameter and connect according to Figure 6 at terminal X1.

14.1 Signal output

The **PMA20** has two signal outputs as standard. One signal is 0-1 V for 100 % O_2 (independent of the chosen measuring range). The second signal is 0-20 or 4-20 mA according to the order with a burden of 300 Ohm for each measuring range. The output signals are not galvanically isolated.

- Lead signal cable with wire cross section 1,5mm² through the right cable gland with clamping range 6-8 mm cable diameter and connect according to Figure 6 at terminal X2.
- Remount lid.

15 Preparations for commissioning

Before initial startup, all plant- and process-specific safety measures must be observed. It is mandatory for the operator to complete the enclosed risk assessment of the product.
The gas exposure risk must be assessed by the operator with regard to the hazards posed by process and calibration gas and the setup at the installation site (e.g. tubing, system cabinet/container/plant). If the risk assessment reveals increased exposure hazards, further measures are required.
A visible label must be attached to the installation site in accordance with the risk assessment provided by the operator.

16 Starting up

- Check electrical connections and gas connections.
- Turn measuring range selection switch from **0** to the desired measuring range. The analyzer is ready for operation immediately.
- Check mechanical zero of the indication; if necessary adjust zero position by turning the slotted screw in the pane of the indication instrument.
- Turn measuring range selection switch to **30 %**.
- Switch on mains voltage.
- The indication instrument shows **21 % O_2** with ambient air in the measuring cell and the LED for heater control lights up permanently.
- After approximately 30 min. the LED in the indication instrument starts flashing. After 12 hours the transmitter has reached a temperature balance and the analyzer is ready for calibration.

17 Calibration

The accuracy of an analyzer mainly is dependent on its calibration.

Note

Before calibration it has to be assured that the calibration conditions correspond to the conditions during measurement. The flow rate and the barometric pressure conditions have to be constant. Under this terms a calibration of the analyzer is necessary aproximately one time a week to maintain the accuracy. If flow rate or barometric pressure conditions are changing significantly, a new calibration is necessary.
During calibration the device must not be exposed to vibrations.

For zero calibration of the analyzer an oxygen-free gas, mostly nitrogen (N_2 5.0) is used.
For span calibration with **M&C** O_2-analyzers it is possible to abandon on special test gas mixtures because of the measuring principle and the linear measuring ranges. Dry and clean air is sufficient. For measurement concentrations > 40 % O_2 a calibration with corresponding test gas could be possibly recommandable.

17.1 Zero calibration

1. Connect a flexible PVC- or FEP-hose with the pressure reducer of the N_2-zero-gas bottle. The pressure reducer should have an output control range of max. 0 – 1.5 bar abs.

Caution

The outlet pressure is only allowed to be adjusted at max. 0.1 bar. Otherwise the measuring cell of the analyzer will be destroyed.

2. Open the bottle valve and than the closed pressure reducer outlet valve and purge the pressure reducer and the complete hose line for approximately 5 sec. the pressure reducer and the complete hose line.
3. Check the adjusted control pressure and reduce if necessary to ≤ 0.1 bar, then shut off the pressure reducer valve again.
4. Connect the hose end of the zero-gas bottle connection to the gas inlet of the analyzer.
5. Open the pressure reducer valve slowly, to avoid pressure peaks.
6. Adjust the flow rate to 50 Nl/h at the flow meter.

Note

Always calibrate at the flow rate that is adjusted for the measurement too.

7. Wait approximately 20 – 30 sec. until the indication has stabilized.
8. Turn measuring range selection switch to position 3 %
9. If necessary adjust zero accurately to 0 % O_2 with a screw driver at the zero potentiometer in the front panel
10. Check output signals at 0.0 % O_2 :

Output signal	Measurement
0-1 V	0 V
0-20 mA	0 mA
4-20 mA	4 mA

Note

If a gas mixture is analyzed, the single gas components have to be checked concerning potential cross sensitivity and regarded for zero calibration. (see chapter 16.1.1 and 16.1.2).

11. Shut off pressure outlet valve and bottle valve.
12. Disconnect hose connection from the analyzer.

Zero calibration is finished.

Note

After zero calibration the span has to be calibrated too.

17.1.1 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	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
Isobutylene	C_4H_8	-0.94	-1.06
Chlorine	Cl_2	-0.83	-0.91
Diacetylene	C_4H_2	-1.09	-1.20
Dinitrogen oxide	N_2O	-0.20	-0.22
Ethane	C_2H_6	-0.43	-0.47

Gas	Formula	20 °C [68 °F]	50 °C [122 °F]
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	-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
Methylene chloride	CH_2Cl_2	-1.00	-1.10
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 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 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 (vapour)	H_2O	-0.03	-0.03
Hydrogen	H_2	+0.23	+0.26
Xenon	Xe	-0.95	-1.02

17.1.2 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 for the zero calibration.

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

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 maid 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%.

Σ = -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:

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

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

1.0526 x -0.1123 vol% = -0.1182 vol%

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.

17.2 Span calibration

Before span calibration a finished zero calibration is necessary.

1. Turn the measuring range selection switch to the measuring range in which the calibration should be done. In case of measuring value concentrations < 30 % O_2 a calibration with dry clean air in the range of 30 % O_2 is recommended. Turn the measuring range selection switch to 30 %. In case of measuring value concentrations > 40 % O_2 a calibration in the 100 % range with adequate test gas is recommended. Turn the measuring range selection switch to 100 %.
2. Connect a flexible PVC- or FEP-hose with the pressure reducer of the N_2-zero-gas bottle. The pressure reducer should have an output control range of max. 0 – 1.5 bar abs.

Caution

The outlet pressure is only allowed to be adjusted at max. 0.1 bar. Otherwise the measuring cell of the analyzer will be destroyed.

3. Open the bottle valve and than the closed pressure reducer outlet valve and purge the pressure reducer and the complete hose line for approximately 5 sec. the pressure reducer and the complete hose line.
4. Check the adjusted control pressure and reduce if necessary to ≤ 0.1 bar, then shut off the pressure reducer valve again.
5. Connect the hose end of the instrument air or check gas bottle connection to the gas inlet of the analyzer.
6. Open the pressure reducer valve slowly, to avoid pressure peaks.
7. Adjust the flow rate to 50 Nl/h at the flow meter.

Note

Always calibrate at the flow rate that is adjusted for the measurement too.

8. Wait approximately 20 – 30 sec. until the indication has stabilized.
9. If necessary adjust span accurately according to the check gas concentration with a screw driver at the span potentiometer in the front panel. In case of air e.g. to 20.9 % O_2.
10. Check output signals at 20.9 % O_2 :

Output signal	Measurement range 100 % O_2	Measurement range 30 % O_2
0-1 V	0.209 V	0.697 V
0-20 mA	4.18 mA	13.93 mA
4-20 mA	7.34 mA	15.15 mA

11. Shut off pressure reducer valve and bottle- resp. Instrument air valve resp. integrated sample gas pump.
12. Disconnect hose connection at the analyzer.

Determination of the output signal:

$$\frac{(S_e - S_{np})\ \text{V resp. mA x gas concentration vol\% } O_2}{\text{upper range value vol\% } O_2} + S_{np}$$

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

13. Shut off pressure reducer output valve and bottle valve. Druckreglerausgangsventil und Flaschenventil schließen. Disconnect hose connection at the analyzer.

The span calibration is finished.

Note

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

Attention

After finishing the calibration turn measuring selection switch to the desired measuring range.
The mA-output signal is dependant on the measuring range!

18 Measuring

For the first starting up at a new location, all steps in chapter 16 and 17 have to be performed.
By the requirements of precision the interval of the new calibration can be carried out daily or weekly.

Caution

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 equipment temperature so that no condensate will occur inside the equipment. If necessary, lower the dew point by means of a cooler or dryer. For dust filtration use a filter of 2 micron porosity!
We will be pleased to inform you about an optimal gas conditioning

The analyzer now is ready for operation.

19 Closing down

In case of a short time closing down of the the analyzer no further precautions are required.
In case of a closing down of the analyzer for a longer period, it is recommended to flush the analyzer with dry and clean inert gas (eg. surrounding air) in order to prevent a damage of the measuring cell by aggressive and corrosive liquid gases.

20 Maintenance

The analyzer, woking with a physical measuring principle, requires no intensive and complex maintenance. But the preceding components necessary for the sample gas conditioning are to be maintained with special attention according to the respective operating manuals.

The calibration of zero and span is to be effected with the corresponding test gases according to stability of the operating conditions and to the demands on the accuracy. Recommended interval of calibration for standard applications: 1 x per week.

21 Trouble shooting

Error	Possible reason	Check/Repair
No indication	No supply voltage	Check supply voltage according to type plate. Check wether mains cable is plugged in accurate. Check fine fuse in the low heat device socket.
No sample gas flow	Sample line or filter is blocked Contamination of the internal diaphragm pump	Check sample system.

22 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.

23 Spare parts list

Wear, tear and replacement part requirements depend on specific operating conditions.
The recommended quantities are based on experience and they are not binding.

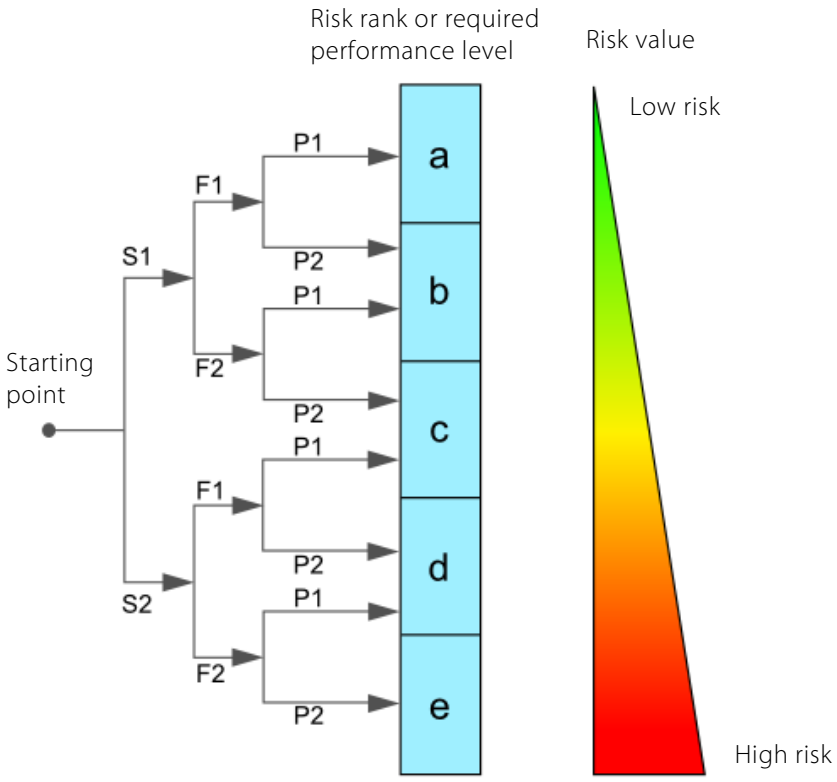
Oxygen analyzer PMA20					
(C) Consumable parts **(R) Recommended spare parts** **(S) Spare parts**					
		Recommended quantity being in operation [years]			
Part No.	**Indication**	**C/R/S**	**1**	**2**	**3**
90A3005	Analog panel meter for PMA20	S	-	-	1
90A2005	Measuring range switch with wiring and front PCB for PMA20	S	-	-	1
90A0020	Zero potentiometer 5 kohm	S	-	-	1
90A0025	Span potentiometer 1 kohm	S	-	-	1
90A0010	Measuring cell type PMC-1 (not for PMA15)	S	-	-	1
90A0015	Flow meter glass for FM40, standard measuring range: 7-70 Nl/h air	S	-	-	1
90A3015	Temperature cutoff 72 °C for PMA20, 25, 30	S	-	-	1
90A3020	Temperature sensor for PMA20, 25, 30	S	-	-	1
05V3230	Bulkhead union, DN 4/6, material: PP	R	2	2	2
05V6500	Ferrule, DN 4/6, material: PP	R	4	4	4
05V6505	Spare union nut, M 10 - DN 4/6, material: PP	R	4	4	4

24 Risk assessment

The risk assessment provided in this chapter is intended for all work activities on the product. The hazards can occur in the work steps of assembly, commissioning, maintenance, disassembly and in the event of a product fault. During normal operation, the product is protected by a system cabinet or appropriate covers. Only qualified personnel is permitted to perform the work. The following minimum knowledge is required for the work:

- Employee instruction provided in process engineering
- Employee instruction provided in electrical engineering
- Detailed knowledge of the instruction manual and the applicable safety regulations

The product complies with the current regulations according to state-of-the-art science and technology. Nevertheless, not all sources of danger can be eliminated while observing technical protective measures. Therefore, the following risk assessment and the description of exposure hazards refer to the work steps mentioned above.



Severity of injury:
S1 = 1 = minor (reversible injury)
S2 = 2 = serious (irreversible injury, death)

Frequency and duration:
F1 = 1 = infrequent or short exposure to hazard
F2 = 2 = frequent (more than once per hour/shift)

Possibility of preventing or limiting the damage
P1 = 1 = possible
P2 = 2 = hardly possible

Figure 7 Overview risk assessment

Aggressive condensate possible

Risk rank group A
Chemical burns due to aggressive media possible!
This applies to all liquids in vessels and in the product.
In general, for electrical and mechanical work on the product, wear personal protective equipment (PPE) in accordance with the risk assessment.

Caution hot surfaces

Risk rank group A

The temperature inside the product can be higher than > 60 °C.
The hot parts are shielded by mechanical devices. Before opening the products, they must be disconnected from the power supply and a cooling time of more than > 20 minutes must be observed. In general, for electrical and mechanical work on the product, wear personal protective equipment (PPE) in accordance with the risk assessment.

Caution electric shock

Risk rank group C

When installing high-power systems with nominal voltages of up to 1000 V, the requirements of VDE 0100 and their relevant standards and regulations must be observed!
This also applies to any connected alarm and control circuits. Before opening the products, they must always be disconnected from the power supply.

Gas hazard

Risk rank group A-B-C

The hazard potential mainly depends on the gas to be extracted.
If toxic gases, oxygen displacing or explosive gases are conveyed with the product, an additional risk assessment by the operator is mandatory.
In principle, the gas paths must be purged with inert gas or air before opening the gas-carrying parts.
The escape of potentially harmful gas from the open process connections must be prevented.
The relevant safety regulations must be observed for the media to be conveyed. If necessary, flush the gas-carrying parts with a suitable inert gas. In the event of a gas leakage, the product may only be opened with suitable PPE or with a monitoring system.
Furthermore, the work safety regulations of the operator must be observed.

Caution crushing hazard

Risk rank group A

The work must be performed by trained personnel only.
This applies to products weighing less than < 40 kg [≈ 88.2 lbs]:
The product can be transported by 1 to 2 person(s). The instructions for appropriate personal protective equipment (PPE) must be observed.
The weight specifications are contained in the technical data of this product.
Furthermore, the work safety regulations of the operator must be observed.

25 Appendix

1. Circuit diagram PMA20
2. Circuit diagram oxygen transducer unit PMA1.02.0
3. Components list circuit diagram PMA1.02.0 (2 figures)
4. Temperature sensor resistance dependent on temperature
5. Installation provisions and spare parts positions

Further product documentation can be seen and downloaded from our home page:
www.mc-techgroup.com

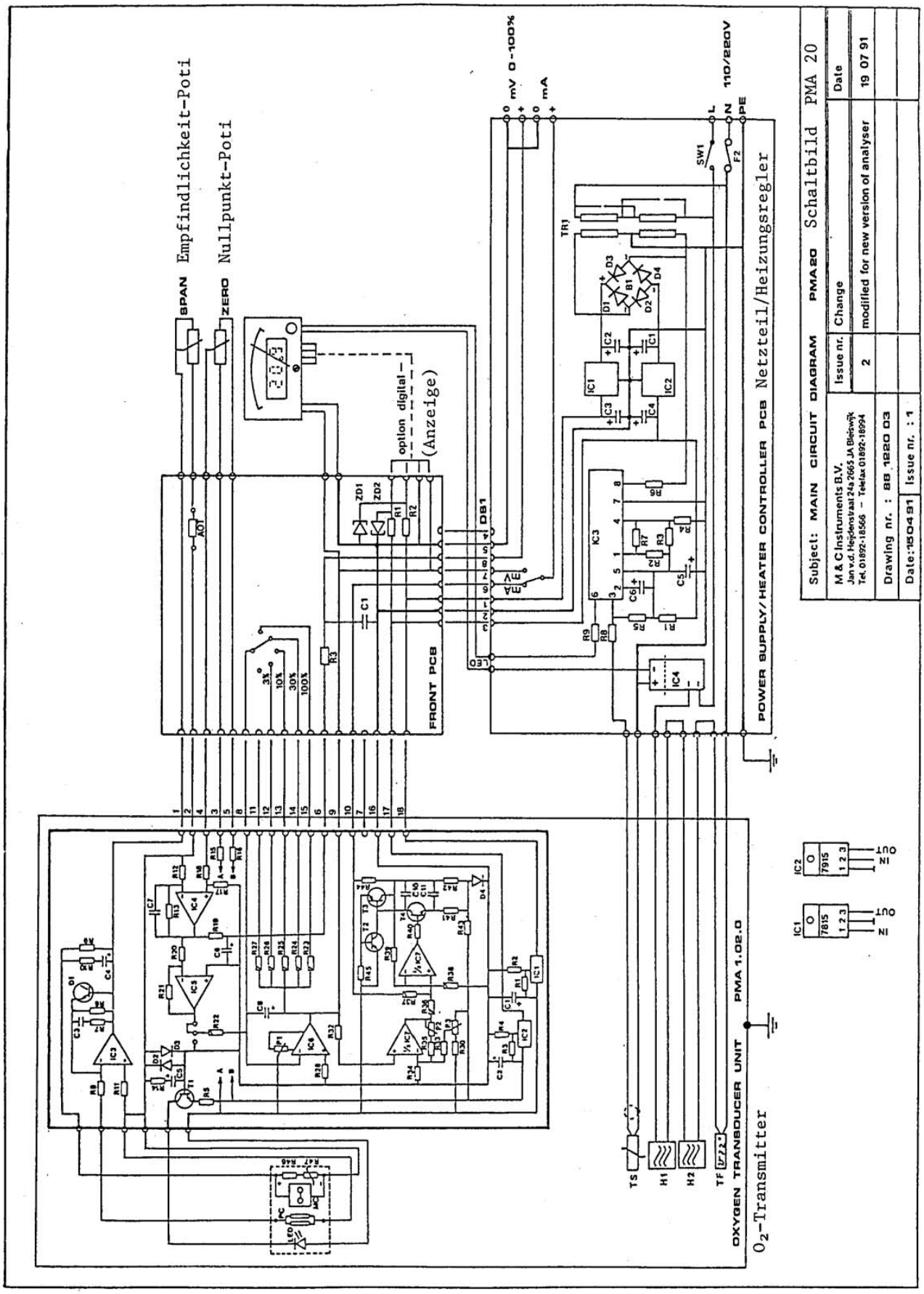
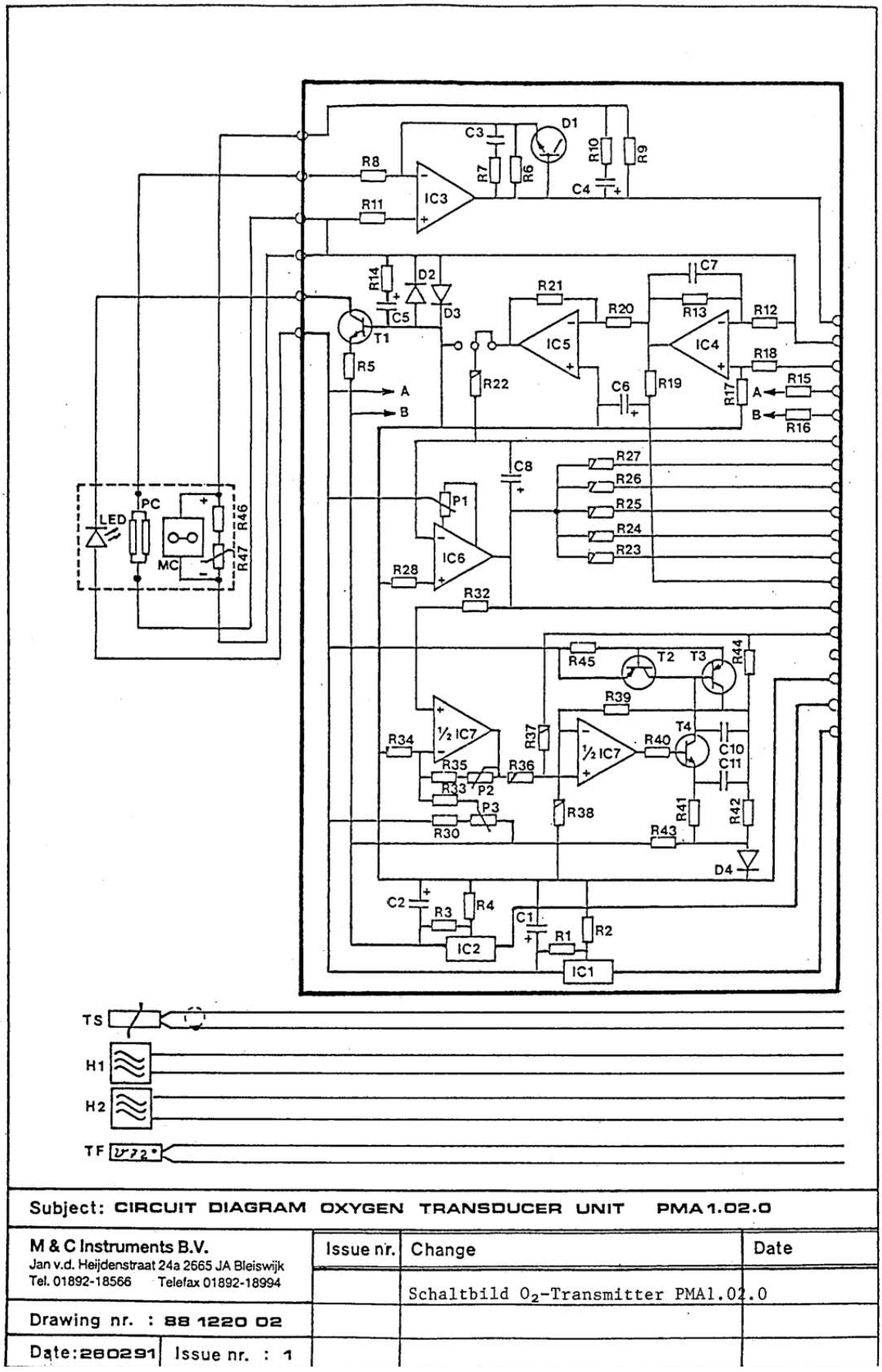


Figure 8 **Circuit diagram PMA20**



Subject: CIRCUIT DIAGRAM OXYGEN TRANSDUCER UNIT PMA1.02.0			
M & C Instruments B.V. Jan v.d. Heijdenstraat 24a 2665 JA Bleiswijk Tel. 01892-18566 Telefax 01892-18994	Issue nr.	Change	Date
		Schaltbild O_2-Transmitter PMA1.02.0	
Drawing nr. : 88 1220 02			
Date:280291 Issue nr. : 1			

Figure 9 **Circuit diagram oxygen transducer unit PMA1.02.0**

C 1		1 µF	16V
C 2		1 µF	16V
C 3		0,68 nF	32V
C 4		100 µF	10V
C 5		22 µF	25V
C 6		47 µF	16V
C 7		47 nF	32V
C 8		1 µF	16V
C 10		1,5 nF	32V
C 11		1,5 nF	32V
D 1	(transistor)	BC 517	
D 2		1N4148	
D 3		1N4148	
D 4		1N4148	
IC 1		LM 317	
IC 2		LM 337	
IC 3		OP 77	alternate AD 707 JN
IC 4		OP 07	alternate AD 707 JN
IC 5		OP 07	alternate AD 707 JN
IC 6		OP 77	alternate AD 707 JN
IC 7		OP221	
P 1		20 K	
P 2		10 K	
P 3		100 K	
T 1		BC 517	
T 2		BC 212	
T 3		2N2905	
R 1		470 E	
R 2		3,9 K	
R 3		3,9 K	
R 4		470 E	
R 5		560 E	
R 6		22 M	
R 7		100 K	
R 8		1 K	
R 9		330 E	
R 10		22 E	

Bestückungsliste O_2-Transmitter PMA 1.02.0

Subject: COMPONENTS LIST CIRCUIT DIAGRAM PMA 1.02.0			
M & C Instruments B.V. Jan v.d. Heijdenstraat 24a 2665 JA Bleiswijk Tel. 01892-18566 Telefax 01892-18994	Issue nr.	Change	Date
Drawing nr. : 88 1220 02			
Date: 060391 Issue nr. : 1			

Figure 10 **Components list circuit diagram PMA1.02.0**

R 11	1 K	
R 12	22 E	
R 13	160 E	
R 14	22 E	
R 15	10 K	
R 16	10 K	
R 17	150 E	
R 18	4 K 7	
R 19	470 E	
R 20	10 K	
R 21	10 K	
R 22	1 K 5	0,1%
R 23	1 K 5	0,1%
R 24	4,49 K	0,1%
R 25	15 K	0,1%
R 26	49,9 K	0,1%
R 27	150 K	0,1%
R 28	1 K	
R 30	8 K 2	
R 32	100 K	
R 33	1 M	
R 34	100 K	
R 35	43,2 K	
R 36	100 K	
R 37	49,9 K	0,1%
R 38	2 K 2	0,1%
R 39	49,9 K	0,1%
R 40	2 K 2	
R 41	10 K	
R 42	10 K	
R 43	10 K	
R 44	47 E	
R 45	22 E	
R 46	27 E	
R 47	47 E	NTC

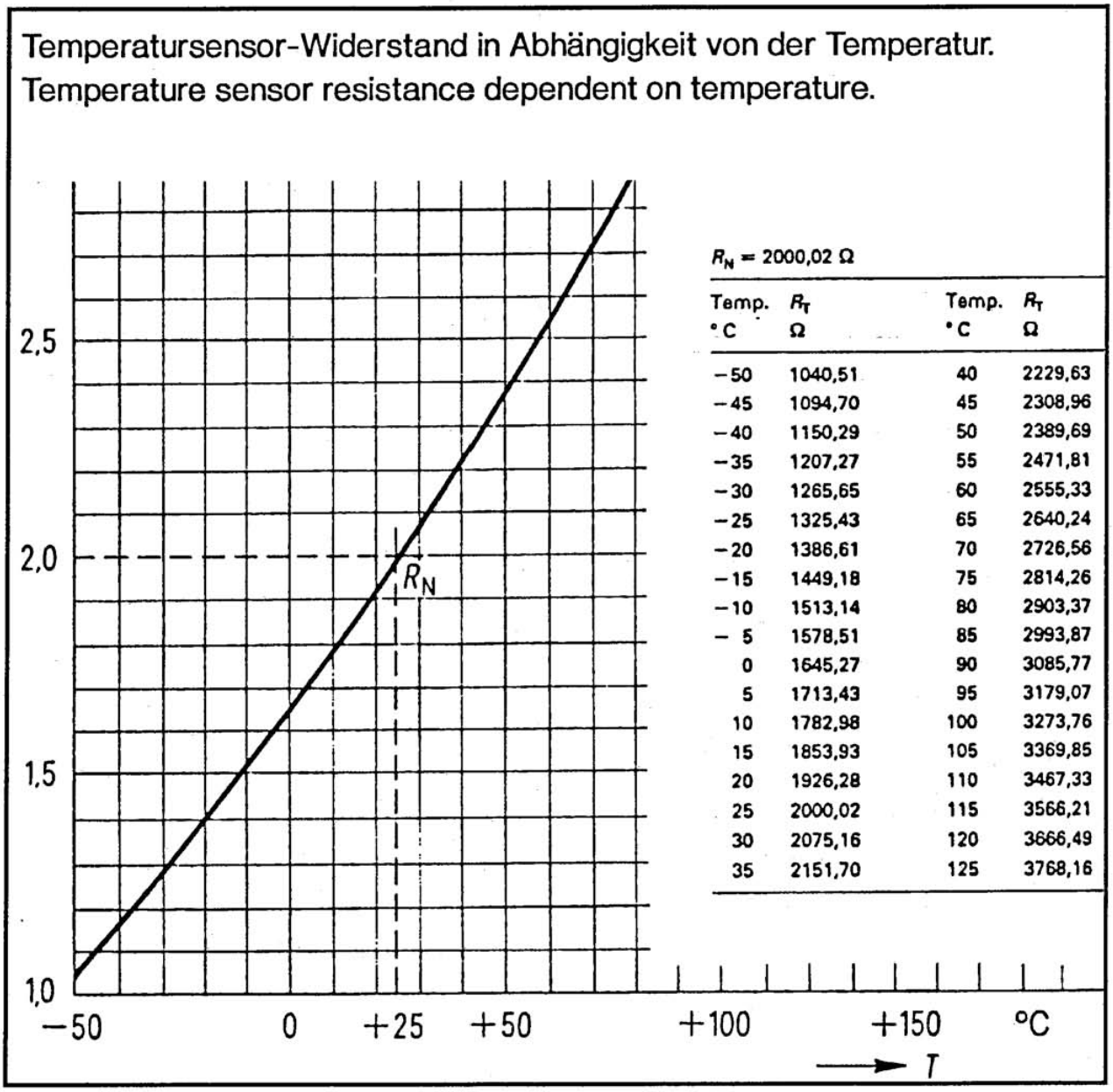
MC	Measuring Cell
PC	Photo-cells
LED	Light Emitting Diode
TS	Temperature Sensor KTY 11
H 1	Heater 110V 12W
H 2	Heater 110V 12W
TF	Thermal Fuse

Bestückungsliste O_2-Transmitter PMA 1.02.0

Subject: COMPONENTS LIST CIRCUIT DIAGRAM PMA 1.02.0

M & C Instruments B.V. Jan v.d. Heijdenstraat 24a 2665 JA Bleiswijk Tel. 01892-18566 Telefax 01892-18994	Issue nr.	Change	Date
Drawing nr. : 88 1220 02			
Date: 060391 Issue nr. : 1			

Figure 11 **Components list circuit diagram PMA1.02.0**



R_N = 2000,02 Ω

Temp. °C	R_T Ω	Temp. °C	R_T Ω
−50	1040,51	40	2229,63
−45	1094,70	45	2308,96
−40	1150,29	50	2389,69
−35	1207,27	55	2471,81
−30	1265,65	60	2555,33
−25	1325,43	65	2640,24
−20	1386,61	70	2726,56
−15	1449,18	75	2814,26
−10	1513,14	80	2903,37
− 5	1578,51	85	2993,87
0	1645,27	90	3085,77
5	1713,43	95	3179,07
10	1782,98	100	3273,76
15	1853,93	105	3369,85
20	1926,28	110	3467,33
25	2000,02	115	3566,21
30	2075,16	120	3666,49
35	2151,70	125	3768,16

Figure 12 **Temperature sensor resistance dependent on temperature**

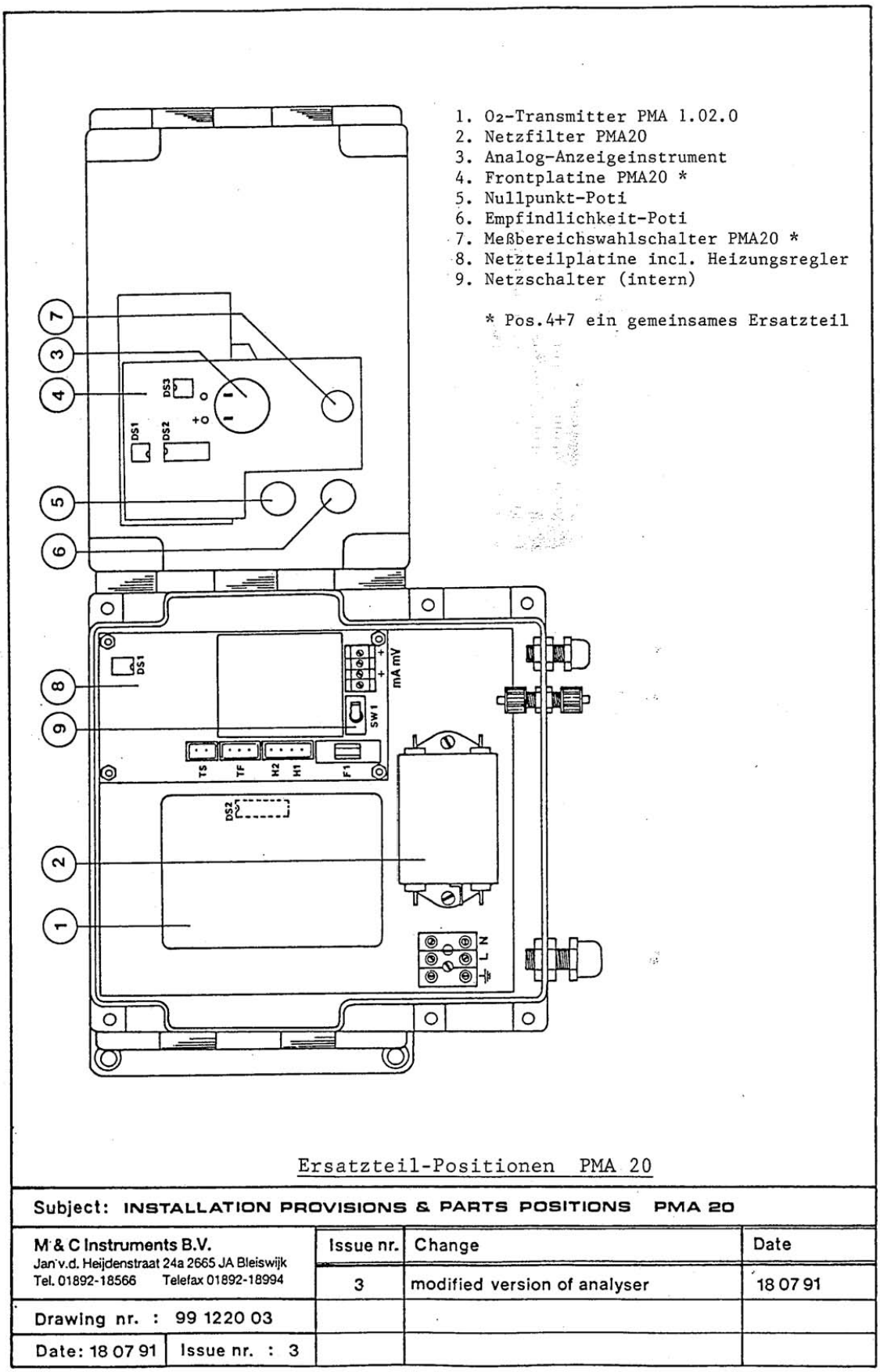


Figure 13 **Installation provisions and spare parts positions**