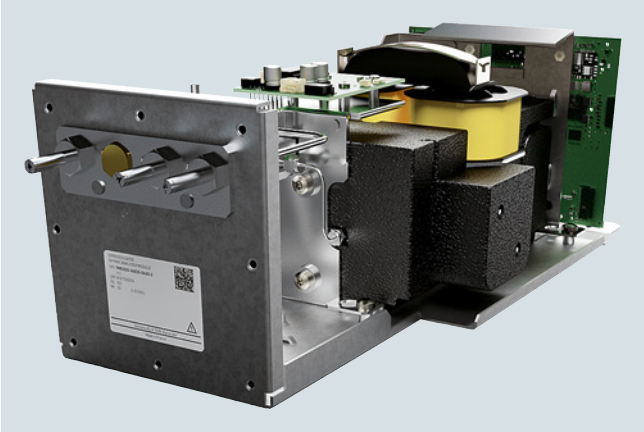
Overview



The function of the OXYMAT 7 module is based on the paramagnetic alternating pressure method and is used to measure oxygen in gases.

Benefits

Paramagnetic alternating pressure principle

- Small measuring ranges (0 to 0.5% or 99.5 to 100% O_2)
- Absolute linearity

Detector element has no contact with the sample gas

- Applicable in the absence of corrosive sample gases
- Long service life

Physically suppressed zero point possible, e.g. in the measuring range 98% or 99.5% to 100% O_2

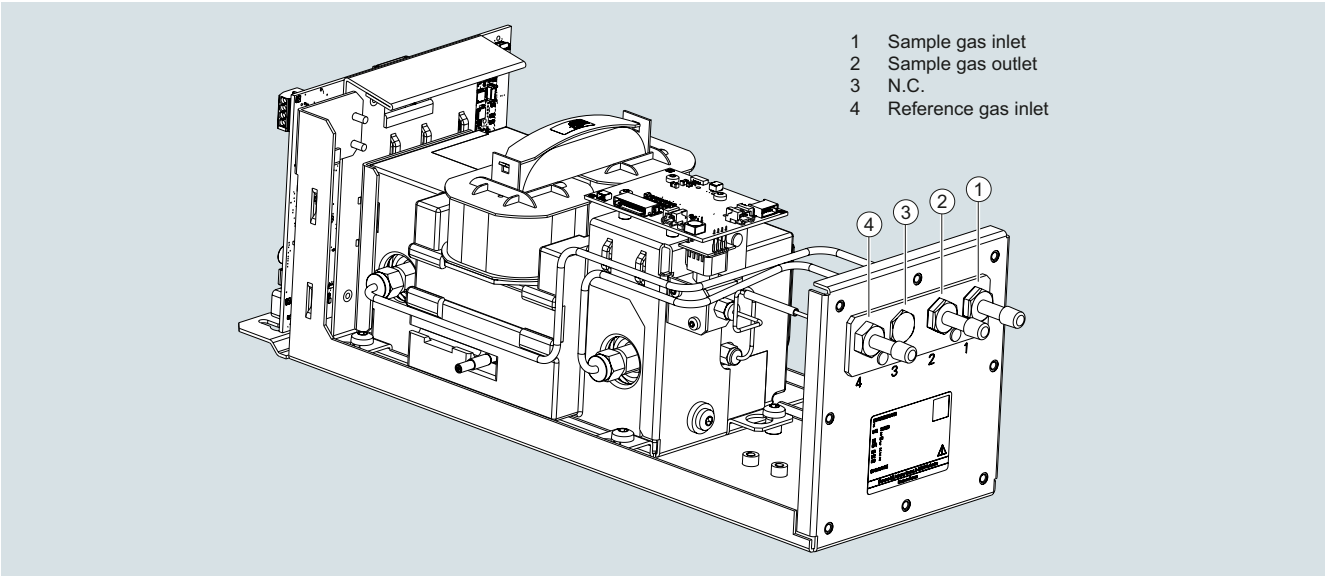
Ex (p) for Zones 1 and 2 according to ATEX-/IECEx approval, introduction of flammable gases possible

Application

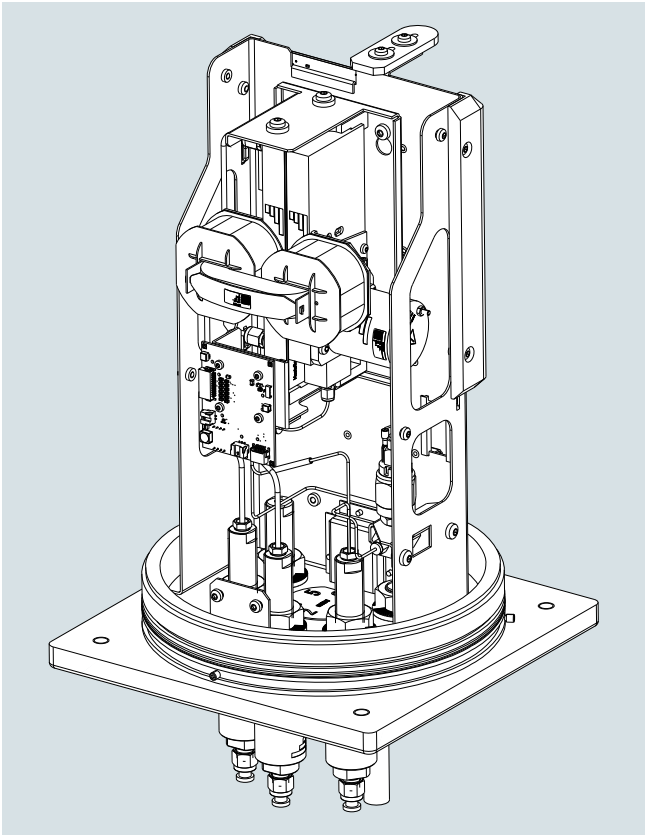
Application areas

- For boiler control in incineration plants
- In chemical plants
- For ultra-pure gas quality monitoring
- In environmental protection
- For quality control
- Purity control/air separator
- Versions for analyzing flammable and non-flammable gases or vapors for use in hazardous areas

Design



Structure of high-pressure version, standard module, sample gas path with pipes

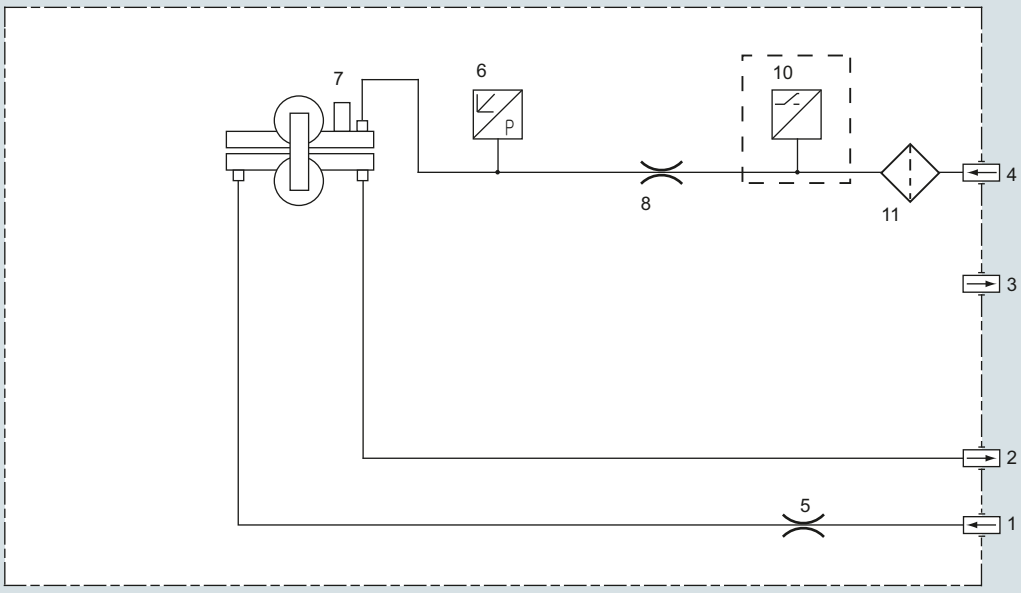


Structure of high-pressure version, field module, sample gas path with pipes

Gas path

High-pressure version with optional pressure switch for monitoring reference gas pressure

Reference gas pressure	2 000 … 4 000 hPa above sample gas pressure, but max. 5 000 hPa
Sample gas pressure	
• With hoses	500 ... 1 500 hPa (abs.)
• With pipes	500 ... 2 500 hPa (abs.) with internal pressure sensor
	500 ... 3 000 hPa (abs.) with external pressure sensor
Sample gas path	With hoses or with pipes

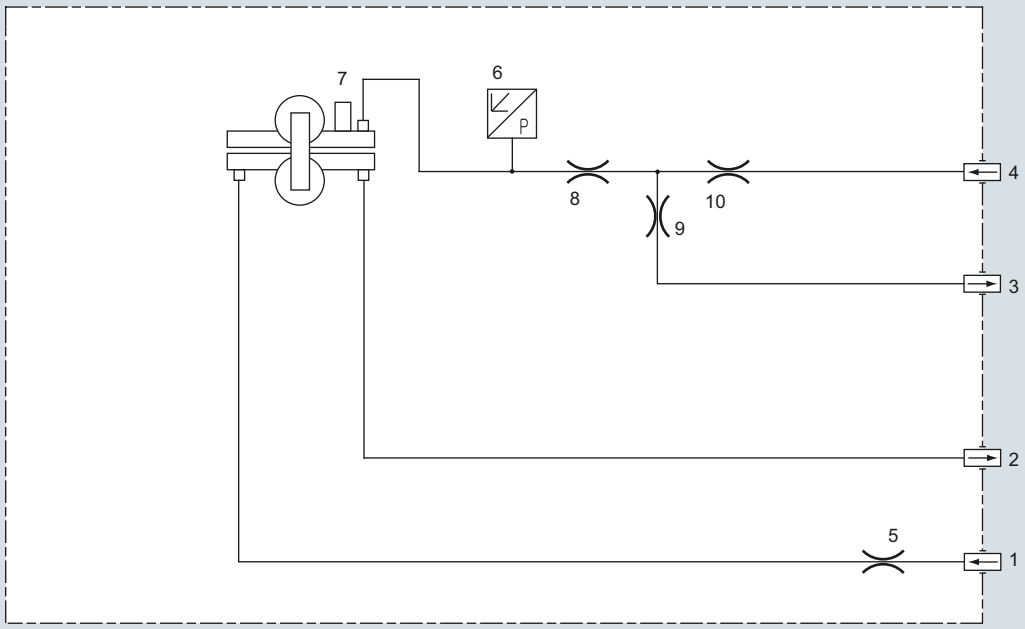


1 Sample gas inlet
2 Sample gas outlet
3 N. C.
4 Reference gas inlet
5 Sample gas restrictor
6 Pressure sensor p for sample gas pressure
7 Analyzer unit
8 Reference gas restrictor
10 Pressure switch for reference gas monitoring (optional)
11 Reference gas fine filter

Gas path plan, high-pressure version with optional pressure switch for monitoring reference gas pressure

Low-pressure version with external reference gas pump

Reference gas pressure	100 hPa above the sample gas pressure (low-pressure version) for the connection of an external pump
Sample gas pressure	Atmospheric pressure ±50 hPa
Sample gas path	With hoses
Reference gas path	With hoses



1 Sample gas inlet
2 Sample gas outlet
3 Bypass outlet
4 Reference gas inlet, external pump, delivery pressure approx. 100 hPa
5 Sample gas restrictor
6 Pressure sensor p for sample gas pressure
7 Analysis part
8 Reference gas restrictor
9 Bypass restrictor
10 Damping restrictor

Gas path plan, low-pressure with external reference gas pump, with hoses

Mode of operation

Oxygen is highly paramagnetic. This outstanding property of paramagnetism is used as a physical measuring effect for oxygen analysis.

Oxygen molecules in an inhomogeneous magnetic field always move toward the higher field strength. This results in a higher oxygen concentration where the field strength is higher (higher oxygen partial pressure). If two gases with differing oxygen content are combined in a magnetic field, a (O_2 partial) pressure difference arises between them.

Since the measuring effect is always based on the difference of the oxygen content of the two gases, one refers to the sample and reference gases.

For measuring oxygen in the OXYMAT 7, the reference gas (N_2, O_2 or air) flows through two channels into the sample chamber (6). One of these partial flows enters the measuring chamber (7) in the area of the magnetic field. If the sample gas is O_2-free, the reference gas can flow out freely. If the sample gas does contain O_2, however, the oxygen molecules concentrate in the area of the magnetic field. The reference gas can then no longer flow off freely. An alternating pressure results between the two reference gas inlets. This pulsates in step with the magnetic field and depends on the oxygen concentration. This causes an alternating flow in the microflow sensor (4).

The microflow sensor consists of two nickel-plated grids heated to approximately 120°C, which, along with two supplementary resistors, form a Wheatstone bridge. The alternating flow results in a change in the resistance of the nickel-plated grids. The resulting offset in the bridge is a measure of the concentration of oxygen in the sample gas.

Because the microflow sensor is located in the reference gas flow, the measurement is not influenced by the thermal conductivity, the specific heat or the internal friction of the sample gas. Additionally, the microflow sensor is protected through this arrangement from corrosion caused by the sample gas.

Further information

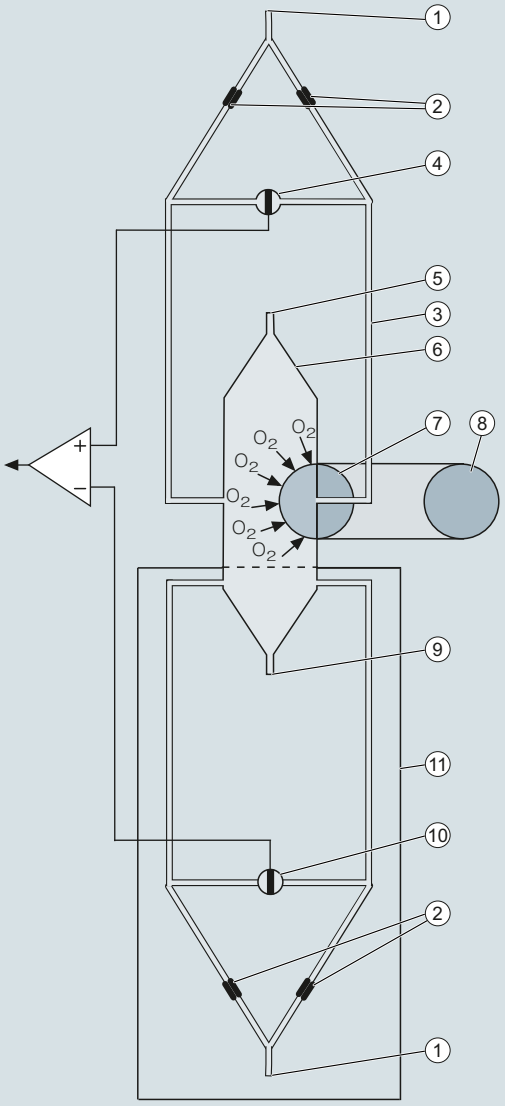
The oscillating magnetic field (8) means that the basic flow at the microflow sensor is not detected. The measurement is, thus, independent of the module's operating position or the position of the sample chamber.

The sample chamber is directly in the sample path and has a small volume, and the microflow sensor is a low-lag sensor. As a result, extremely short response times are realized.

Vibrations at the installation site can interfere with the measured signal (e.g. large fluctuations in the output signal). This behavior can be compensated for by a second (optional) microflow sensor (10), which functions as a vibration sensor. Since large differences in density between the sample and reference gases further amplify the undesired influence of vibration, reference gas is channeled to both the compensation microflow sensor (10) and the sample microflow sensor (4).

The sample gases must be fed into the analyzers free of dust. Condensation in the sample chambers must be prevented. Therefore, the use of gas modified for the measuring task is necessary in most application cases.

Flowing reference gas prevents the microflow sensor from being damaged and maintains the measurement capability of the module.



1 Reference gas inlet
2 Restrictors
3 Reference gas channels
4 Microflow sensor for measured signal
5 Sample gas inlet
6 Sample chamber
7 Source of the paramagnetic measuring effect
8 Electromagnet with alternating current strength
9 Sample gas and reference gas outlet
10 Microflow sensor in the vibration compensation system (order variant)
11 Compensation circuit (optional)

OXYMAT 7, principle of operation

Essential characteristics

Technical features

Depending on the reference gas, the physical zero point can be set between 0% and 100% oxygen.

- Smallest measuring spans (up to 0.5% O_2) possible
- Measuring ranges with physically suppressed zero points possible (e.g. 99.5% to 100%)
- Short response time
- Low long-term drift
- Monitoring of reference gas pressure with reference gas connection 2 500 to 5 000 hPa (abs.) (option): reference gas pressure must be 2 000 ± 150 hPa higher than the sample gas pressure.

Features

- Internal pressure sensor for correction of pressure variations in sample gas in the range from 500 to 2 500 hPa (absolute)
- External pressure sensor - only with piping as the gas path - can be connected for correction of variations in the sample gas pressure up to 3 000 hPa absolute (option)
- Monitoring of reference gas (option)
- Analysis part with flow-type compensation circuit as an order variant for reducing the vibration impact at the installation site
- For sample gas path with hoses: Connection cable to the pressure sensor with hoses
- Hardware adapted to application
- Customer-specific analyzer options such as:
  - Clean for O_2 service (specially cleaned gas path)
  - Kalrez-6375 seals

Reference gases

Measuring range	Recommended reference gas	Reference gas connection pressure	Comments
0 to ... vol.% O_2	N_2	2 000 … 4 000 hPa above sample gas pressure (max. 5 000 hPa absolute)	The reference gas flow is set automatically to 5 … 10 ml/min (up to 20 ml/min with flow-type compensation branch)
... to 100 vol.% O_2 (suppressed zero point with full-scale value 100 vol.% O_2)	O_2		
Around 21 vol.% O_2 (suppressed zero point with 21 vol.% O_2 within the measuring span)	Air	100 hPa with respect to sample gas pressure, which may vary by max. 50 hPa around the atmospheric pressure	

Table 1: Reference gases for OXYMAT 7

Correction of zero-point error/cross-sensitivities

Accompanying gas (concentration 100 vol.%)	Zero point deviation in vol.% O_2 absolute
Organic gases	
Ethane C_2H_6	-0.49
Ethene (ethylene) C_2H_4	-0.22
Ethine (acetylene) C_2H_2	-0.29
1.2 butadiene C_4H_6	-0.65
1.3 butadiene C_4H_6	-0.49
n-butane C_4H_{10}	-1.26
iso-butane C_4H_{10}	-1.30
1-butene C_4H_8	-0.96
iso-butene C_4H_8	-1.06
Dichlorodifluoromethane (R12) CCl_2F_2	-1.32
Acetic acid CH_3COOH	-0.64
n-heptane C_7H_{16}	-2.40
n-hexane C_6H_{14}	-2.02
Cyclo-hexane C_6H_{12}	-1.84
Methane CH_4	-0.18
Methanol CH_3OH	-0.31
n-octane C_8H_{18}	-2.78
n-pentane C_5H_{12}	-1.68
iso-pentane C_5H_{12}	-1.49
Propane C_3H_8	-0.87
Propylene C_3H_6	-0.64
Trichlorofluoromethane (R11) CCl_3F	-1.63
Vinyl chloride C_2H_3Cl	-0.77
Vinyl fluoride C_2H_3F	-0.55
1.1 vinylidene chloride $C_2H_2Cl_2$	-1.22
Inert gases	
Helium He	+0.33
Neon Ne	+0.17
Argon Ar	-0.25
Krypton Kr	-0.55
Xenon Xe	-1.05
Inorganic gases	
Ammonia NH_3	-0.20
Hydrogen bromide HBr	-0.76
Chlorine Cl_2	-0.94
Hydrogen chloride HCl	-0.35
Dinitrogen monoxide N_2O	-0.23
Hydrogen fluoride HF	+0.10
Hydrogen iodide HI	-1.19
Carbon dioxide CO_2	-0.30
Carbon monoxide CO	+0.07
Nitrogen oxide NO	+42.94
Nitrogen N_2	0.00
Nitrogen dioxide NO_2	+20.00
Sulfur dioxide SO_2	-0.20
Sulfur hexafluoride SF_6	-1.05
Hydrogen sulfide H_2S	-0.44
Water H_2O	-0.03
Hydrogen H_2	+0.26

Table 2: Zero point error due to diamagnetism or paramagnetism of some accompanying gases with reference to nitrogen at 60 °C und 1 000 hPa absolute (according to IEC 1207/3)

Conversion to other temperatures:

The deviations from the zero point listed in Table 2 must be multiplied by a correction factor (k):

- with diamagnetic gases: $k = 333\ K / (\varphi\ [°C] + 273\ K)$
- with paramagnetic gases: $k = [333\ K / (\varphi\ [°C] + 273\ K)]^2$

All diamagnetic gases have a negative deviation from zero point.

Technical specifications

The technical specifications are based on the definitions of DIN EN 61207-1.

Unless specified otherwise, the data listed below relates to the following measurement conditions:

Ambient temperature	25 °C
Atmospheric pressure	Atmospheric (approx. 1 000 hPa)
Sample gas flow	0.6 l/min (or Nl/min)
Reference gas	Nitrogen
Site of installation	Vibration- and impact-free

General information	
Weight	Approx. 5.5 kg (standard version)
Measuring ranges	
Number of measuring ranges	Max. 4; parameters can be assigned freely
Parameters can be assigned in the measuring ranges	
• Smallest possible measuring spans	0.5%, 1%, 2% or 5% O_2
• Largest possible measuring span	100% O_2
Gas inlet conditions	
Sample gas pressure	
• Standard devices with hoses	500 … 1 500 hPa (abs.)
• Standard devices with hoses and ext. RG pump	Atmospheric pressure ± 50 hPa
• Standard devices with pipes	500 … 3 000 hPa (abs.); briefly < 5 000 hPa (abs.)
• Field module	
- For non-combustible gases	500 … 2 500 hPa (abs.)
- For combustible gases up to gas mixtures which are occasionally explosive	800 … 1 100 hPa (abs.)
Reference gas pressure	
• High-pressure connection	2000 hPA above sample gas pressure (within permitted reference gas pressure range 2500 to 5000 hPa, abs.)
• Low-pressure connection with external reference gas pump	100 hPa above sample gas pressure
Pressure drop between sample gas inlet and sample gas outlet	< 100 hPa at 1 l/min
Sample gas flow	18 … 60 l/h (0.3 … 1 l/min)
Sample gas temperature	0 … 60 °C
Sample gas humidity (rel. humidity)	< 90% (condensation inside the gas path is to be avoided)
Sample chamber temperature	
Standard version	Approx. 72 °C
Time response	
Warm-up period at room temperature	< 2 h
Response characteristics	
• Display delay T_{90} with an electronic damping setting of 0 s and a sample gas flow of 1 Nl/min.	≤ 1.9 s; ≤ 2.4 s (field module including flame arrestor)
• Dead time T_{10}	≤ 1.1 s; < 1.6 s (field module)
Measuring response	
Output signal fluctuation with static damping constant of 0 s and dynamic noise suppression of 5% / 10 s	≤ ±0.5% of smallest measuring span (noise bandwidth corresponds to 1% = 6σ value or 0.333% = 2σ value), with vibration compensation activated: < 1.5 times the value
Detection limit	≤ 1% of smallest measuring span according to nameplate (with vibration compensation activated: < 1.5 times the value)

Measured-value drift	
• At the zero point	≤ ±0.5% of the smallest span/month or ≤ ±50 vpm O_2/month, whichever is greater
• For span gas	≤ ±0.5% of the current measuring span/month or ≤ ±50 vpm O_2/month, whichever is greater
Repeatability	
• At the zero point	≤ ±0.5% of the smallest measuring span/month or ≤ ±50 vpm O_2/month, whichever is greater
• For span gas	d≤ ±0.5% of the current measuring span/month or ≤ ±50 vpm O_2, whichever is greater
Linearity error with dry ambient air[1)]	< 0.1%
Influencing variables	
Ambient temperature	
• Deviation at zero point	≤ 0.5% of the smallest measuring span / 10 K or ≤ 50 vpm O_2/10 K, whichever is greater
• Deviation of the span gas	≤ 0.5% of the current measuring span / 10 K or ≤ 50 vpm O_2/10 K, whichever is greater
Sample gas pressure	
• Deviation at zero point	≤ 0.2% of the smallest measuring span / 1% pressure variation or ≤ 50 vpm O_2/1% pressure variation, whichever is greater
• Deviation of the span gas	≤ 0.2% of the current measuring span / 1% pressure variation or ≤ 50 vpm O_2/1% pressure variation, whichever is greater
Sample gas flow	
• Deviation at zero point	≤ 1% of smallest measuring span per 0.1 l/min change in flow or ≤ 50 vpm O_2 per 0.1 l/min change in flow within the permissible flow range (0.3 to 1 l/min), whichever is greater
• Deviation of the span gas	≤ 1% of current measuring span per 0.1 l/min change in flow or ≤ 50 vpm O_2 per 0.1 l/min change in flow within the permissible flow range (0.3 to 1 l/min), whichever is greater
Accompanying gases	Zero point deviation (cross-sensitivity) in accordance with Table A.1 of EN 61207-3
Supply voltage	< 0.1% of the current measuring span (within the nominal range of use)
Electrical inputs and outputs	
Analog and digital interfaces	See base unit
Gas connections	
Connection fittings	Pipe connection with 6 mm outer diameter
Climatic conditions	
Storage and transport	-30 ...70 °C
Permissible ambient temperature[2)]	0 ... 50 °C
Relative humidity (RH) during storage, transport or operation	< 90% (condensation from the installed components is to be avoided)

1) Untreated ambient air contains less than 20.95% O_2 (literature value) since existing humidity of the oxygen content is decreased relatively.

2) Restriction for installing together with an ULTRAMAT 7 module: 5 ...45 °C

1

OXYMAT 7 module

Selection and ordering data			Article No.	Cannot be combined
OXYMAT 7 module			↗ **7MB3020-** ■■■■**0 -** ■**AA**■	
For measurement of oxygen				
↗ Click on the Article No. for the online configuration in the PIA Life Cycle Portal.				
Module version				
Standard module (for rack mounted and wall enclosure)			**0**	
Standard module for hazardous zone (for rack mounted and wall enclosure)			**2**	**2** **2**
Field module for field housing Ex d without purging gas connections			**4**	**4**
Reference gas pressure				
Low-pressure version 100 hPa (for the connection of an external pump; without pressure switch)			**A**	**A** **A** **A**
High pressure (2 000 ... 4 000 hPa above sample gas pressure)			**C**	
High pressure (2 000 ... 4 000 hPa above sample gas pressure), with pressure switch			**D**	
Smallest possible measuring span				
0.5 %			**B**	**B**
1 %			**C**	**C**
2 %			**D**	
5 %			**E**	
Gas path				
Material of gas path	Material of sample chamber	Material of seal		
Hose made of FKM (Viton)	Stainless steel (1.4571)	FKM (Viton)	**0**	**0** **0** **1**
Pipe made of stainless steel (1.4404)	Stainless steel (1.4571)	FKM/Ex: Kalrez (6375)	**1**	
Pipe made of Hastelloy C22	Hastelloy C22	Kalrez (6375)	**2**	**2**
Vibration compensation				
Without			**0**	**0**
With			**1**	
Version				
Standard			**0**	

Selection and ordering data	Order code
Additional versions	
Add "**-Z**" to Article No. and specify Order code	
Settings	
Kalrez (6375) seals in sample gas path	**B04**
Clean for O_2 service (specially cleaned gas path)	**B06**
Measuring range indication in plain text, if different from the default setting	**Y11**
Exclusively for measuring non-toxic sample gases	**Y16**
Base unit module assignment number	**D00 ... D99**

Ordering example

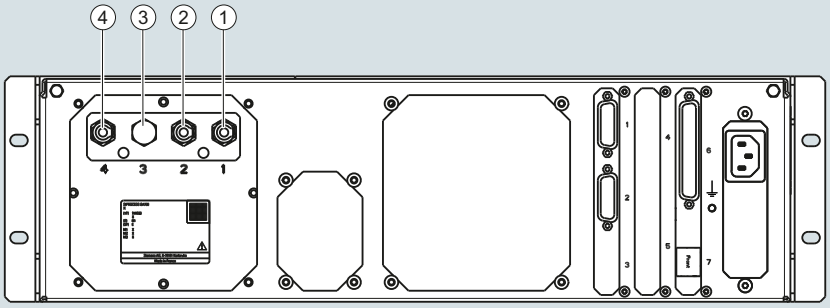
OXYMAT 7 module installed in wall enclosure
7MB3000-3CX00-1AA0-Z+D02
7MB3020-0CE00-0AA0-Z+D02

OXYMAT 7 module and ULTRAMAT 7 installed in rack unit enclosure
7MB3000-0CB00-1AA0-Z+D05
7MB3020-0CE00-0AA0-Z+D05
7MB3010-0CA10-0AA0-Z+D05

OXYMAT 7 module and wall enclosure supplied separately
7MB3000-3CX00-1AA0
7MB3020-0CE00-0AA0

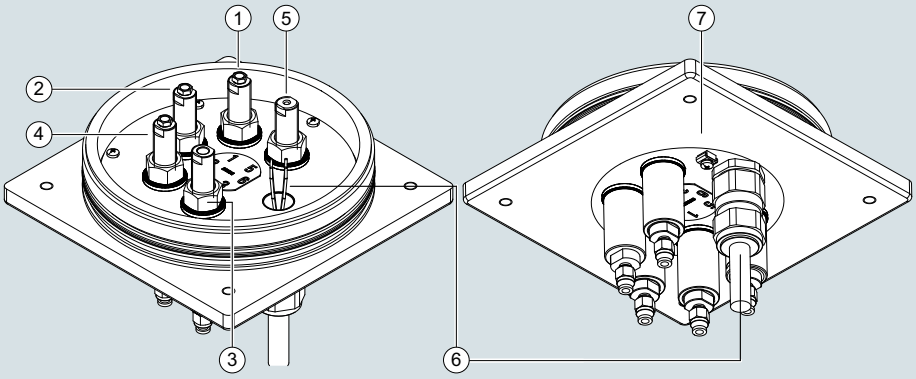
Circuit diagrams

Gas connections



1 Sample gas inlet
2 Sample gas outlet
3 N.C., bypass outlet for version with external reference gas pump
4 Reference gas inlet

Gas connections for sample gas inlet and outlet, reference gas: Fittings, 6 mm pipe diameter



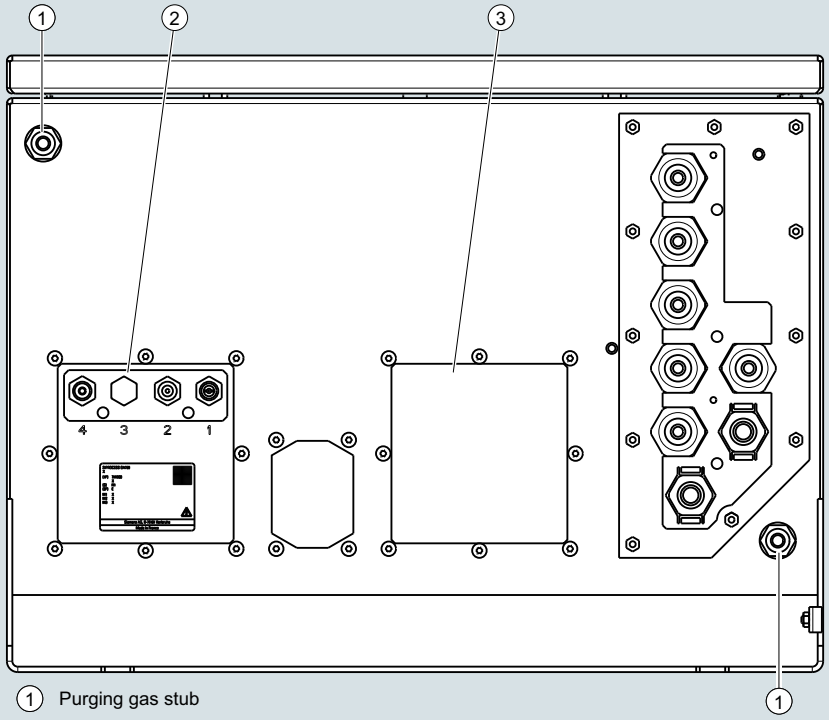
1 Sample gas inlet
2 Sample gas outlet
3 Blanking plug or purging gas connection
4 Reference gas inlet
5 Breathing apparatus (pressure compensation coupling)
6 Cable bushing
7 Ground connection

The sample gas connections are made of stainless steel Mat. No. 1.4571 or Hastelloy Mat. No. 2.4819.
The reference gas connection is made of stainless steel Mat. No. 1.4571.
Gas connections are fitted with a clamping ring screw connection for 6 mm pipes.

Gas connections of the field module

OXYMAT 7 module

Wall-mounted device



1 Purging gas stub
2 Slot of module 1: OXYMAT 7
3 Slot of module 2

Wall-mounted device, bottom