Operating Instructions

Oxygen Measuring System

AR420-O-Zr

Read prior to operation!

Observe all safety instructions!

Keep for further reference!

CE

red line
Dr. Markus Kieninger
Vogelsangstr. 8
73666 Baltmannsweiler

Tel.: 07153 / 92 96 670
Tel.: 07153 / 92 96 671
Fax: 07153 / 94 50 25

www.alpha-redline.de
info@alpha-redline.de

Table of contents

1. For your safety

Please follow the instructions!

Any person handling or operating the oxygen measuring system must first be fully familiar with and observe these instructions for use. The oxygen measuring system is to be used only for the described purpose (see chapter 1.2).

Servicing

The oxygen measuring system must be inspected and serviced regularly by qualified specialists. Repairs to the oxygen measuring system are allowed to be carried out by the manufacturer only, (see chapter 1.4 and 5.).

Do not operate in areas subject to explosion hazards!

The oxygen measuring system is not approved for operation in areas subject to explosion hazards.

Warning!

These operating instructions do not contain all the information necessary for the safe operation of the device. Please make yourself acquainted with the regulations and operator's obligations that apply in your area. In addition to these operating instructions, for example, you should observe and instruct others concerning the universally valid legal and other binding regulations for the prevention of accidents and protection against accidents.

1.1. Safety information and tips

A series of warnings is used in these instructions concerning some of the risks and dangers that may occur when using the oxygen measuring system. These warnings contain "signal words" designed to draw attention to the degree of danger that is to be expected.

These signal words and the associated hazards are as follows:

⚠	**DANGER!** Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.

⚠	**WARNING!** Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

	CAUTION! Indicates a **potentially** hazardous situation which, if not avoided, **may** result in **minor or moderate injury**. It may also be used to alert against unsafe practices.

	IMPORTANT! Indicates information concerning use and other useful information.

1.2. Intended use

The oxygen measuring system AR420-O-Zr was especially designed for the control of oxygen concentration in rooms (ambient).

The oxygen measuring system AR420-O-Zr may exclusively be used for:

- Measuring the oxygen concentration in ambient air in a temperature range of -20° to 60°C.
- Measuring the oxygen concentration in ambient air or in inert gas mixtures (N_2, CO_2, noble gases)

The oxygen measuring system AR420-O-Zr is not suitable for determining the oxygen concentration in an explosive atmosphere.
Please always mount the oxygen measuring system as described in chapter 3.3 and definitely observe the ambient conditions stated therein (e.g. temperature limits).

	DANGER! **Danger to life due to lack of oxygen!** Oxygen is vital to human beings. The air to breathe should contain more than 17 vol-% oxygen. Considerably lower concentrations will cause slow or quick death by asphyxiation. Users and operators of the facility must make sure that, where the concentration of oxygen is too low, suitable measures are taken to protect people in accordance with legal regulations.

	WARNING! **Danger of fire and explosion due to sparks!** The oxygen measuring system AR-O-Zr may not be operated in areas where ignitable or explosive gas mixtures can arise.

WARNING!

Oxygen measuring systems are safety devices and may be repaired by the manufacturer only. Do not modify the oxygen measuring system and do not reconstruct it. Otherwise the oxygen measuring system might no longer measure the oxygen concentration reliably.

IMPORTANT!

The sensor in the oxygen measuring system contains zirconium dioxide and platinum and can be destroyed by the catalyst poisons listed in chapter 4.6. These substances must **not** be contained in the gas mixture that is to be measured!

IMPORTANT!

The measuring signals from the oxygen measuring system must be evaluated and further processed by the user's downstream device.

IMPORTANT!

It is essential to observe the information given in these operating instructions with regard to operation, maintenance and servicing.

Troubles must be eliminated immediately as they could affect safety.

1.3. Residual hazards

Although the oxygen measuring system has been constructed carefully, some dangers will remain while using the device. The following of these dangers are known to us:

DANGER!

Mains voltage (230V, 50Hz).
Danger to life due to electric shock or burns.
Do not bring into contact with water.
Before opening the oxygen measuring system, ensure that no hazardous voltage is present.
Electrical work should only be carried out by qualified electricians.
Only install in a voltage-free state.

Caution!

The probe tube is hot (200°C).
Risk of burns and fire!
Please wear protective gloves.
During mounting keep an adaequate distance between the probe tube and combustible materials.
Take the device out of operation immediately if the probe protection tube is damaged.

1.4. Qualification of staff

Only qualified engineers or persons with comparable qualification may mount, install or commission the oxygen measuring system, or carry out maintenance and servicing work.

Only qualified electricians may carry out work on the electrical system according to VDE, UL or similar regulations.

The operator must instruct all users of the system on the basis of these operating instructions.

An experienced person must supervise juveniles and apprentices when working on the oxygen measuring system.

Any work not described in this operating instruction must be executed by the manufacturer.

i	**IMPORTANT!** The oxygen measuring system is a safety device and may be repaired by the manufacturer only. Do not modify and do not reconstruct the gas measuring system. Otherwise the gas concentration could not be reliably measured.

2. Product description

2.1. Design of the oxygen measuring system

The measuring system consists of the aluminum housing (1) with the cable entry (2) on one side and an approx. 75mm probe protection tube (3) made of stainless steel on the opposite side. The probe protection tube prevents accidental contact to the heated sensor element by the user. The sensor element is additionally protected against mechanical damage or impurities by a sinter. An advantageous gas convection, pumping effect, results from the coincidence of probe protection tube with the outlet holes and the hot sinter.

Fig. 1 Oxygen measuring-system AR420-O-Zr

The electronics are installed in the housing, which are:

- Signal amplifier,
- Control unit for the ion pump with an analog part,
- Test component (Test / Pin 5),
- Internal monitoring logic component,
- Power supply for the sensor heating element, as well as for the analog and digital part, • Reset- and voltage monitor
- Bi-directional digital output (channel K2 or Pin 3)
- Analog output with 4-20mA or 0-10V (channel K1 or Pin 4).

The output signals from the oxygen measuring system are read and processed according to the customer's specifications in a downstream device.

2.2. Principle of function

The oxygen measuring system AR420-O-Zr measures the oxygen partial pressure directly in the gas mixture, the absolute oxygen content. If the air pressure remains stable, the measuring result equals the oxygen concentration in vol.-%. The measuring process is based on a dynamic operation between two zirconium dioxide discs, which form a hermetically sealed chamber.
The entire measuring range is linear.

Since the measuring system monitors its own functioning during operation and defined malfunctions of the hardware and sensor are reported, as well as a diagnostic function, it can be operated safely when required. A second oxygen sensor is not needed for this purpose!
Calibration can be carried out without reference gas in atmospheric air.

The measured values are exported via an analog (4-20 mA or 0.1-10 V) and a digital channel, with the latter also transmitting the fault messages. The measuring device internally has a visual display indicating the state of the digital I / O signal from K2.

2.3. Technical Data

Transmitter		
Power supply	Screw terminal 5-digit	Conductor gauge size (rigid and flexible) 0,5mm² up to 2,5mm²
	voltage / tolerance	24 VDC ±20%
	Electrical power	approx. 11,5W
Connections	Screw terminal 1	+24VDC
	Screw terminal 2	0V
	Screw terminal 3	K2 Digital I/O Impulse and fault, electric calibration
	Screw terminal 4	K1 Analog output linear 0-10V or 4-20mA
	Screw terminal 5	Test
	Test spot K1 TP1	Indirect measurement of the output current more then 10Ω (±0,2%)
Cable routing	For Ø 4-10mm	
Measuring range	0.1 – 25Vol.-% Oxygen at 1013.25 hPa, 1 – 253.31hPa(O_2)	
Gas entrance	By Diffusion	
Warm up time	5min Accuracy K1	
	±2% FS at 25° and 1013.25 hPa	
Ambient temperature	-20°C to +60°C	Mind solar radiation!
Permissible humidity	0 to 95% relative humidity	Non condensing
Air pressure	800 to 1100hPa	
Output	4-20mA, max. burden 500Ω or 0-10V, impedance 1000Ω	
Resolution	DAC Resolution 12 bit	
Housing	Aluminium, red	
Housing protection class	IP 54	
Weight	approx. 600g	
Size housing	approx. L90 x B85 x H65 mm	Without probe and screw connection
Probe protection tube	Length	approx. 75mm
	Diameter	approx. 30mm
	Material	Stainless steel

2.4. Certifications

The oxygen measuring system AR420-O-Zr complies with the EMC standard DIN EN 50270:2015-10 type1 and type2 and thus the EMC directives 2014/30/EU (see 10.1.)

3. Transport und Installation

3.1. Transport

The oxygen measuring system is supplied together with these operating instructions. Please check the packaging for any damage when the product is delivered and report any damage immediately to the forwarding agency and dealer. The oxygen measuring system should not be thrown or dropped as it could be damaged or scratched. Protect against wet conditions, humidity, dirt and dust.

3.2. Storage

The oxygen measuring system should be stored in its packaging in dry rooms at temperatures between +10°C and +50°C. Protect it against wet conditions, humidity, dirt and dust.

i	**IMPORTANT!** Silicone-containing substances must not be stored in the same room as the oxygen measuring system; heavy metals or saline materials must not be stored close to the system, as these substances can destroy the sensor (see section 4.6.).

3.3. Mounting

The mounting location must be chosen depending on the application. If, for example, the concentration of oxygen in the ambient of a nitrogen-filled cryotank is to be measured for the purpose of personal protection, at least one oxygen measuring system must be installed near the tank in height of head and another at ground level, as cold nitrogen is heavier than air.
The oxygen measuring system must be installed on a flat, firm and dry surface. The probe protection tube always points to the ground, so that no standing moisture can form on the probe protection tube.
During installation, care must be taken that the ambient conditions for the oxygen measuring system are complied with, see section 2.3 Technical data.
The measuring system must be sufficiently accessible for maintenance and calibration.

i	**IMPORTANT!** The housing must be visible and freely accessible at all times. When the system is mounted outdoors, it must be protected from the weather.

The oxygen measuring system must not come into contact with water for a longer period!
The device must not be accessible to dust as this will block the filter at the bar probe and cause the oxygen measuring system to make erroneous measurements!
The sensor must be protected against splashing water. Condensation on the sensor can shorten the lifetime.
The ambient air must not contain any harmful substances; see chapter 4.6, as these will contaminate the oxygen sensor.
The measuring system must be protected from direct solar radiation.
The oxygen measuring system must not be installed in damp locations or areas subject to explosion hazards.

CAUTION!

At ambient temperatures above 40°C there is a risk of burning at the housing of the measuring system, housing temperatures might be above 60°C. The device should not be touched. Safety measures must be taken for maintenance and calibration.

3.4. Electrical connection

DANGER!

Mains voltage (230V, 50Hz).
Danger to life due to electric shock or burns.
Do not bring into contact with water.
Before opening the oxygen measuring system, ensure that no dangerous voltage is applied.
Electrical work should only be carried out by a qualified electrician.
Only install in a voltage-free state.

The connection between measuring system and downstream unit must be equipped with a fix installed, five core and shielded cable. Do not mount this cable next to a hightension power cable as there is a danger of radiated interference. The cable must be capable of withstanding the anticipated mechanical, chemical and thermal stresses. The cable cross-section must be designed in such a way that the minimum voltage supply at the plug connection is always present.
The power supply has to be designed, to garantee the maximum switch-on current of 1.25A (for oxygen measuring system is in cold state at 19.2V), and the inrush charging pulse of approximately 10A (at 28.9V for approx. 5 ms).

IMPORTANT!

The country-specific requirements for the installation must be considered by the user.

For basic operation, connect the oxygen measuring system to the supply via Pin 1 and Pin 2 (see Fig.2) and read the measured data via K1 Pin 4 (4-20 mA or 0,1-10 V). This for example can be done with the help of a measuring instrument, a PLC (programmable logic controller) or a GWZ-Sx.1 (limit monitor).

For safely operation, Pin 5 (test) and Pin 3 (K2, digital output) have to be connected as well. Then the output signals are monitored and processed in a logic unit connected by the user. Between the terminals Pin 5 (Test), Pin4 (K1) and Pin 3 (K2) and the DC power supply must be at least 40Ω.
Output signal of the oxygen measuring system is 4-20 mA or 0-10 V.

i	**IMPORTANT!** There must be a constant supply of power to the oxygen measuring system, otherwise condensate will arise, and this can destroy the oxygen measuring system.

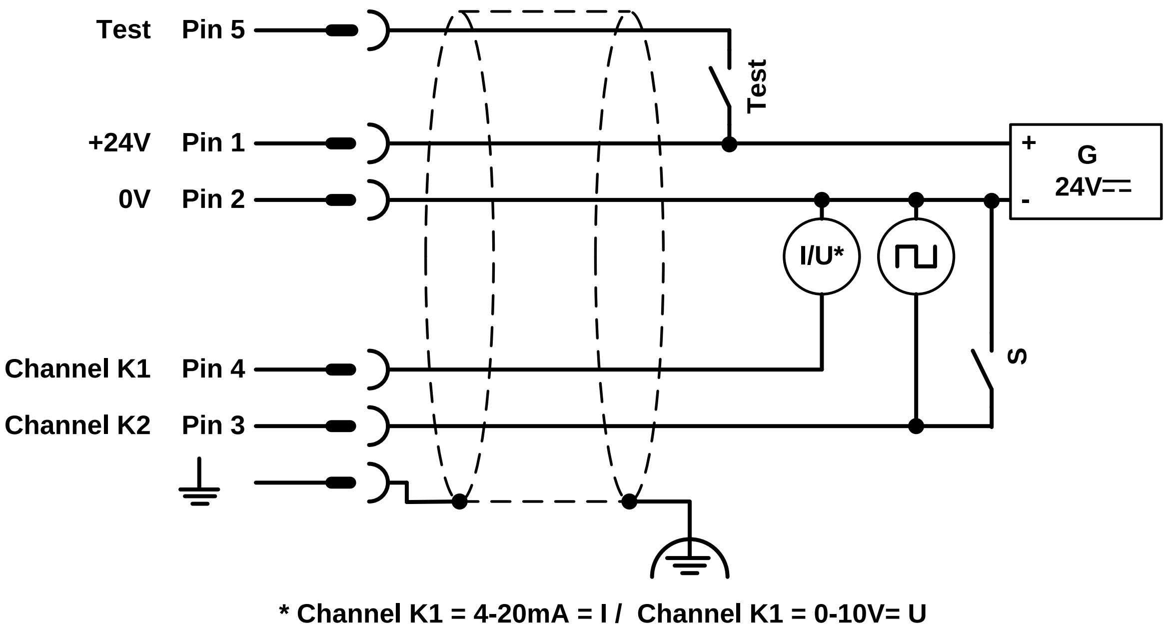


Fig. 2 Pin assignment of AR420-O-Zr

⚠	**CAUTION!** In accordance with existing safety regulations, the oxygen measuring system must only be connected to a suitable power supply unit that complies with the valid technical regulations. It must be ensured that a fuse protection is provided which is suitable for the power supply unit used (SAFE ELECTRICAL ISOLATION)!

3.4.1. Output K1

The signal at K1 outputs the oxygen concentration corresponding to the measuring range used, it can be converted as shown in the table (Fig. 3). K1 can be designed as 4-20mA current loop or 0- 10V voltage output depending on the version.

Measuring range	Current 4-20mA	Voltage 0-10V
0.1 - 25Vol.% O_2 bei 1013.25hPa	$c[Vol.\%] = \frac{I[mA] - 4mA}{16mA} * 24.9vol.-\% + 0.1vol.-\%$	$c[Vol.\%] = \frac{U[V]}{10V} * 24.9vol.-\% + 0.1vol.-\%$
1 - 253.31hPa O_2	$c[hPa] = \frac{I[mA] - 4mA}{16mA} * 252.31hPa + 1hPa$	$c[hPa] = \frac{U[V]}{10V} * 253.31hPa + 1hPa$
c = measured concentration		

Fig. 3 Conversion K1

3.4.2. Digital I/O channel K2

A bidirectional signal is available with channel K2. It displays the status, as well as a comparison value for channel K1 and can activate the electrical calibration as an input signal.

Output signal	Information
High	No successful ‚electric calibration‘
Alternating	OK, the probe is in operation, the dynamic process is active. The low phase corresponds to the oxygen concentration
Low	Fault, the monitoring functions of the system have detected a malfunction.

Fig. 4 Signal states for K2

The duration of the signal “low phase” is proportional to the oxygen concentration. The maximum low-phase of a performing system is less than 1.5s. The total cycle of the alternating system for a performing system is less than 4s.

The parameters for conversion into a concentration are system-specific. They can be taken as x0 and x100 value in [ms] from the additional label. The measured low-time t_L can be converted into the concentration as follows.

$$c = \frac{(t_L[ms] - x0)}{(x100 - x0)} * measuring\ range\ end\ value$$

IMPORTANT!

The measured value K2 is less accurate and more dependent on interference influences than the measured value K1.

K2 -Signal	Min.	Type	Max.	
U_{High} Output	4V	5V	5.5V	Signal at the high-phase of the output K2 or if the electrical calibration is not successful I_{High}
Output			1.5mA	
U_{Low} Output			1V	Signal at the low phase of the output K2 or at fault.
U_{Low} Input	-0.5V		0.6V	Signal for the short circuit during the electrical calibration
I_{High} short circuit			10mA	

Fig. 5 Signal K2

3.4.3. Determine the parameters for conversion

For the determination of the parameters for the conversion of K2 into a concentration, two different test gases out of the measuring range must be streamed up and the times has to be determined.

The concentration c_1 can be used as the first measuring point for the calibration, the time T_{C1} being determined in this case. A value of approx. 20% of the measuring range is recommended as the second concentration c_2. Example: For the measuring range 25 vol.-% a concentration of approx. 5 vol.-%. For this purpose, the low phase T_{C2} is determined.

With these values the parameters x0 and x100 are determined as follows:

$$x0 = T_{c1} - \frac{T_{c1} - T_{c2}}{c_1 - c_2} * c_1$$

$$x100 = \frac{t_{c1} - T_{c2}}{c_1 - c_2} * measuring\ range\ end\ value + x0$$

3.4.4. Test (external test)

The oxygen measuring system is designed in a way that it can check its own proper function during operation. The sensor signal is selectively altered by means of the external test, and the measuring system must show this change in the output signals. The system further measures the concentration during the external test, means changes of concentration additionally have an effect on the signal output. Pin 5 (test) must be connected for the external test (see Fig. 2).

Carry out the external test:

- Memorize concentration K1 and time of K2.
- Apply +24V to pin 5. As a result, the probe will display a lower oxygen concentration than actually present.
- The output signal has a delay of approx. 6 clock cycles.
- At the analog output K1, the indicated concentration must decrease by approx. 20%.
- At the digital output K2, the indicated measuring signal must decrease by more than approx. 10%.
- If this is not the case, the measuring system is defective and must be replaced.
- After the test, switch off the +24V on pin 5.
- The output signal has a delay time of about 6 clock cycles until it returns.

The function test is usually performed cyclically. The value tolerance for the decrease of K1 during external test is 20% ±4%.

i	**IMPORTANT!** During the test, this criterion can lead to errors during channel comparison.

i	**IMPORTANT!** While testing, the concentration should be kept constant. Changes in the gas concentration lead to a deviation which influences the result.

Test-Signal	Min.	Type	Max. U_{High}	Input
	18.0V	24.0V	28.8V	Test funktion is active.
I_{High} Input			13mA	
U_{Low} Input	-5V	0V	3V	The test function is deactivated. An internal resistor pulls the input to low signal.
I_{Low} Input	-1mA		1.0mA	

Fig. 6 Level signal test

3.4.5. Shield-connection, FE-connection

The shield is connected directly to the housing by the contact springs of the cable gland. If the shield is conbected to functional earth, as shown in Fig. 2, no further functional earth connection is necessary.

Fig. 7 Left with standard cables, right with thin cables

In the case of standard cables (Fig. 7), the outer jacket and the shield are removed first. At a length of approx. 15 mm, the outer jacket will provided with a round cut and the cable inserted into the screw connection. After this the outer jacket is pulled off and the cable is retracted until a connection is made between the line screen and the contact spring.

For thin lines without an inner cable jacket (Fig. 7) first the outer cable jacket is first removed. The shield braid is pulled about 20 mm over the outer jacket and the cable is inserted into the screw connection until a connection is made between the line shield and the contact spring.

As an alternative, the device internally offers a screw, via which the functional earth can be connected.

3.4.6. Test point K1 TP1

By means of the test point, the output current can be determined by using a potential-free voltage measuring device. For this, the measuring input of the measuring device is connected to the pin,+' and the' Com' connection to the pin,-'. The output current of K1 is then as follows:

$$I_{K1}[mA] = \frac{U_{TPK1}[mV]}{10\Omega}$$

i	**IMPORTANT!** The precision of the voltage meter, the tolerance of the calibration gas used and the 10Ω resistance, see section 2.3, determines the measuring error of the oxygen measuring system during the recalibration.

4. Operation

4.1. Commissioning

Before commissioning use the following list to check whether all requirements for trouble-free operation are met:

- Has the oxygen measuring system been installed?
- Is the housing of oxygen measuring system accessible and visible?
- Have the ambient conditions been taken into account?
- The connecting cable is not laid next to electric power line?
- Has the oxygen measuring system been connected correct?
- Is the power supply switched on?
- After operation start of the system, carry out a check of the measure function.
- Create a protocol of start of operating (see section 10.3, Warranty).

i	**IMPORTANT!** Taking into account the height of the installation location above sea level, the measuring system displays the correct oxygen partial pressure. The concentration display, in vol.-%, is lower for higher installation locations, because of the lower overall pressure since the calibration is carried out to a pressure of 1013.25hPa.

4.2. Check of the measure function

For the check of the values, the measuring system has to be fumigated by a defined gas concentration and reviewed, the measured result have to be correspond with the concentration. For check can be used e.g. atmospheric fresh air.
If the measured value is within the permissible tolerances, the device is ready for operation.
If the measured value is outside this range, make a calibration (see chapter 4.3) and an external test (see chapter 3.4.3). If this does not help, inform the manufacturer or dealer.

4.3. Calibration

The measuring system is designed in a manner, that no additional calibration is required even if the device is in operation for a long period of time. If required, a manual or an electric calibration is possible.

i	**IMPORTANT!** The measuring system measures the oxygen partial pressure. According to Dalton's Law, the oxygen partial pressure depends on the air pressure and relative humidity. Strong fluctuations of these parameters affect the calibration!

4.3.1. Manual calibration

i	**IMPORTANT!** A change of potentiometer settings results in a change of the parameters x0 and x100 for K2.

Manual calibration is performed with a potentiometer P1, see Fig.8, inside the housing. Steps for manual calibration:

- Aeration the sensor with a defined oxygen concentration. To achieve good results a concentration greater than half of the measuring range is recommended.
  This may be for example, atmospheric fresh air with a typical concentration of 20.7vol.-% of oxygen, see chapter 4.5.2.
- Make sure that the voltage supply is safe. Then unscrew the housing open.
- The potentiometer P1 is used to adjust the output signal at K1. The current value can be determined by means of the test point K1 TP1, see section 3.4.4. The voltage value can be measured directly at the screw terminals.

Measuring range	Current 4-20mA	Voltage 0-10V
0,1 - 25Vol.-% O_2 bei 1013.25hPa	$I[mA] = \frac{c - 0{,}1vol.-\%}{24.9vol.-\%} * 16mA + 4mA$	$U[V] = \frac{c - 0{,}1vol.-\%}{24.9vol.-\%} * 10V$
1 - 253.31hPa O_2	$I[mA] = \frac{c - 1hPa}{252.31hPa} * 16mA + 4mA$	$U[V] = \frac{c - 1hPa}{252.31hPa} * 10V$
c = defined oxygen concentration in the required unit of measurement		

For a measuring range up to 25vol.-%, a current signal of 17.24mA or a voltage signal of 8.27V must be set for a concentration of 20.7vol.-% at 1013.25 hPa.

- Close the housing.
- If K2 is used for concentration comparison, the new parameters for the conversion must be determined, see chapter 3.4.2.1.
- The aeration of the measuring system with a defined concentration can be terminated.

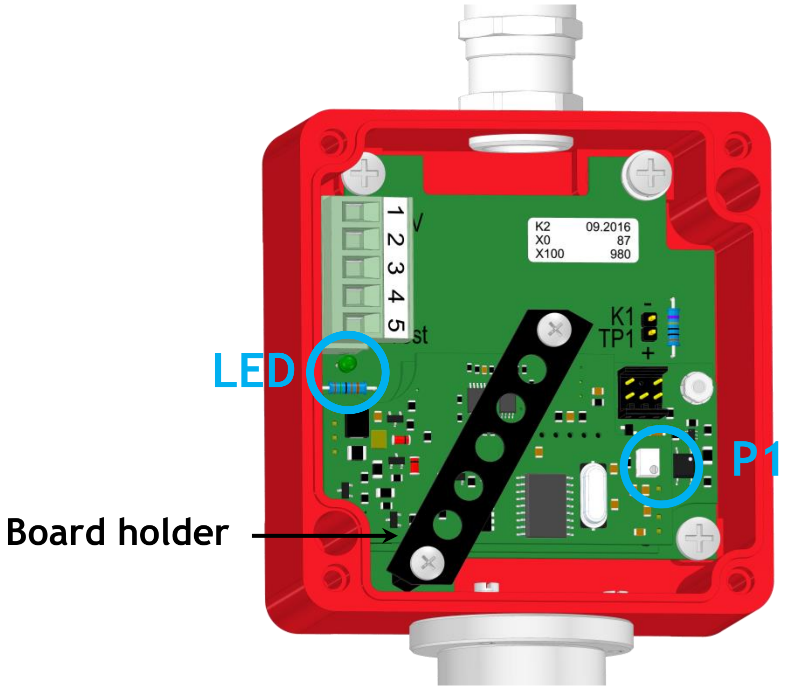


Fig. 8 Potentiometer for setting of concentration

4.3.2. Electrical calibration

The AR420-O-Zr offers a simple calibration of the signal K1 with a fixed concentration, the so called 'electrical calibration'. To use this function, pin 3 must be connected and the system must be fumigated with the calibration gas.

Measuring range	Concentration for calibration
0.1 – 25vol.-% O2 bei 1013.25hPa	20.7vol.-% O_2, corresponds to the typical concentration of atmospheric air
1-253.31 hPa O_2	209.7hPa O_2

Fig. 9 Concentration for 'electrical calibration'

A conversion value for the output signal is re-determined during readjustment. The conversion value may only change by ± 20% compared to the potentiometer hardware setting. To carry out the 'electrical calibration' the system must not be disturbed, see 3.4.2 Digital I / O K2.

Steps for electrical calibration:

- Connect AR420-O-Zr for at least 30 seconds plus the reaction time (T90) to the calibration gas.
- Close switch S (Pin 3 or channel K2) for at least 10 seconds by a downstream device. Now the oxygen measuring system will calibrate itself.

- Open the switch S.
- If the system has successfully calibrated itself, it indicates, that the output signal of K1 shows the test gas concentration taking into account a tolerance, while K2 outputs an alternating signal.
- If the system could not be successfully calibrated, no signal change occurs at K1, and on K2 is put out a high signal, see Fig. 10.
- The aeration of the measuring system with a defined concentration can be terminated.

If the electrical calibration failed, the required conversion value is outside the permissible tolerances. The reason therefore might be the following:

Reason	Possible error detection	Action
Incorrect calibration gas concentration dispensed.	Control of the calibration gas	If necessary, use the correct calibration gas and try again.
The system has not yet been supplied with the calibration gas for a sufficiently long time.	The measuring signal of K1 still rises or falls over time.	Repeat electric calibration.
The conversion value permanently is out of tolerance.	Despite a stable K1 signal, it was not possible to achieve an electrical calibration.	Perform manual calibration.

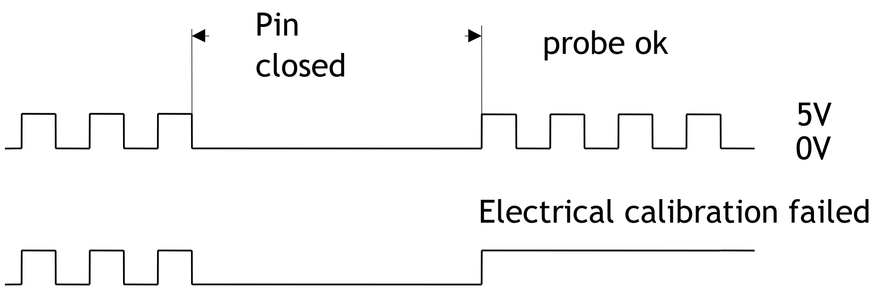


Fig.10 Signal output K2 at electrical calibration

4.3.3. Calibration-adapter

The accessory 'calibration adapter' facilitates gas delivery for measurement control and calibration with test gases from a gas bottle.

i	**IMPORTANT!** The calibration adapter must be connected to the test gas bottle with a suitable gas pipe and a removal valve. These are not parts of the calibration adapter.

The calibration adapter is placed on the probe protection tube. A slight rotation of the adapter makes it easier to attach. Connect to the test gas bottle so that a flow of approx. 0.5 l/min flows through the calibration adapter. The oxygen measurement system is thereby exposed to the defined test gas concentration.

i	**IMPORTANT!** Make sure that the holes of the probe protection tube are open. Otherwise, no gas exchange can take place, which leads to a faulty measurement.

4.4. Diagnostic functions

If necessary, the oxygen measuring system can be operated self-diagnostic.

How does the oxygen measurement system detect errors?

The oxygen measuring system emits two measuring signals via two different channels:
- The measured value is available as an analog signal (4-20mA or 0-10V) at signal K1,
- On the bidirectional signal K2 as a digital, pulse-length-modulated rectangular signal.

The oxygen measuring system works without errors, if the analogue signal of K1 corresponds to the signal of the digital channel K2 (maximum deviation 4%FS). If the rectangular signal (low + high) falls from out a time window of 0.05 to 4s, or is statically low or high, a fault has occurred.
Since the measuring method is dynamic, the proper function of the oxygen measuring system can be veryfied out at any time, even during operation, with the aid of the so called "external test" and is to carried out typically cyclic (see Fig. 11).

i	**IMPORTANT!** When comparing the signals, especially for signal jumps, the different signal transit times between K1 and K2 of approx. 6 clock cycles have to be considered.

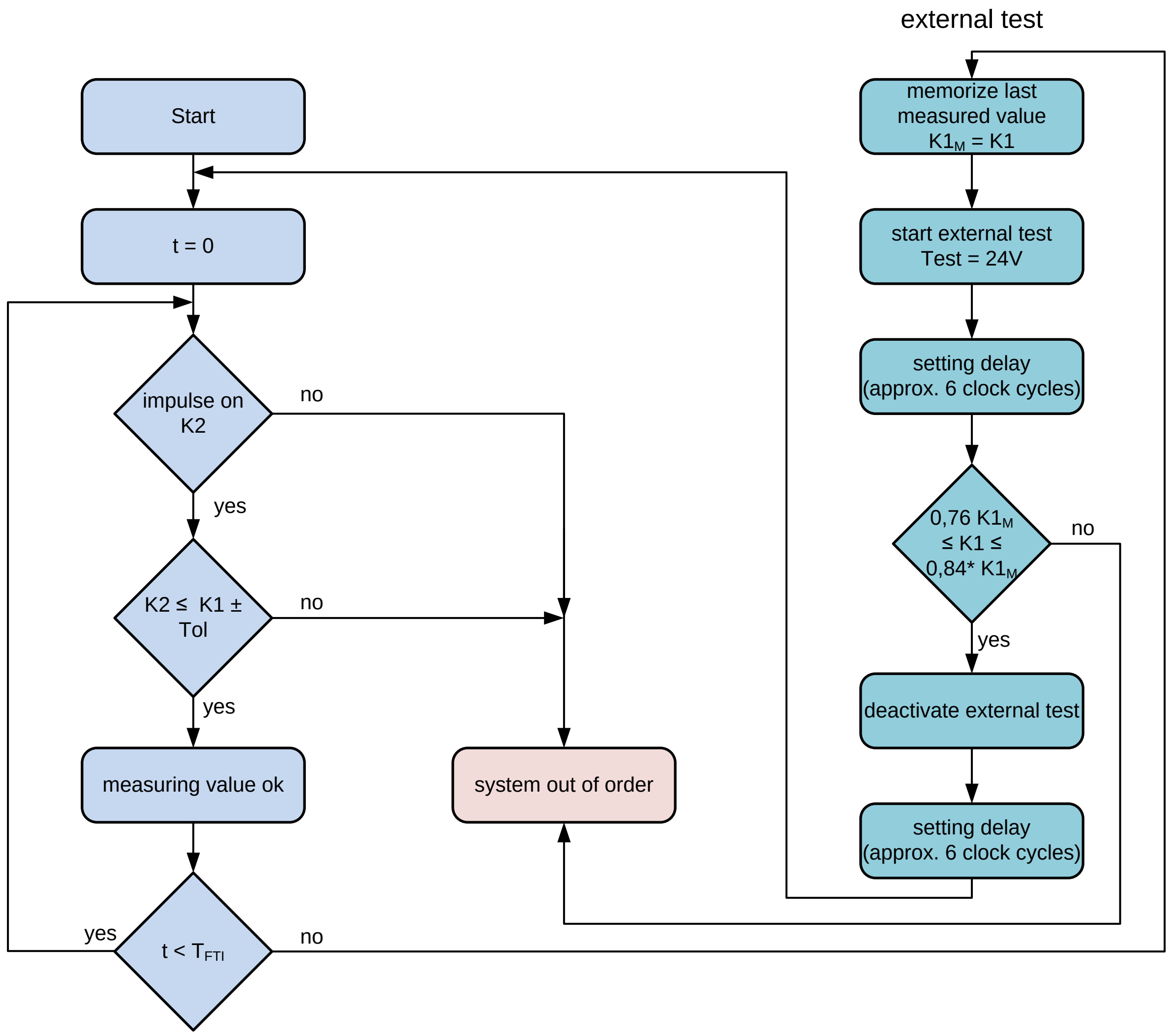


Fig. 11 Flow-chart: External test for function control of the oxygen measuring system.
K1 = signal K1 [Vol.-%]; K2 = signal K2 [Vol.-%]; T_{FTI} = time interval for external system test. The interval depends from the application; $K1_M$ = measuring value of K1 before start oft he external test.

This test arrangement makes it possible not only to discover failurs on the hardware of the measuring system, but also on the sensor itself, i.e. also on the zirconium dioxide chamber!

When does the oxygen measurement system work fail safe?

The oxygen measuring system monitors its entire system itself during operation and also gets along with only one oxygen sensor.
It works fail safe when:

- the analog and digital output signals are identical (see Fig. 12),
- the measuring signal of the K2 is within a defined time window and if it is not static,
- the foreign test is carried out cyclically and correctly.

Oxygen measuring system ready for operation			
	Measuring signal channel K1	Measuring signal channel K2	Difference Measuring signal (K1-K2)
Normal operation (Test Low)	linear (4-20mA or 0-10V)	digital and length of the Low+High phase 0,05-4s	Difference <4%FS
External test active (Test High)	Displayed concentration decreases by approx. 20%	Measuring value [ms] decreases at least by 10%	
Oxygen measuring system out of order			
	Measuring signal channel K1	Measuring signal channel K2	Difference Measuring signal (K1-K2)
Normal operation (Test Low)		no impulse or length of the Low + High phase < 0,05 respectively >4 s.	Difference > 4%FS
External test (Test High)	Change of the displayed concentration is out of range	No descent of the measuring value by more than 10%	

Fig 12: Error messages of the oxygen measuring system

External monitoring unit of the user

An external monitoring unit connected downstream by the user must carry out the evaluation of the measuring signals, as well as the execution and monitoring of the cyclic external test. The reaction to an error message is according to the specifications of the user and is also managed by its external monitoring unit.

Therefore it must satisfy certain requirements:

- The unit must be fail-safe; this means, the operations listed below must be executed without errors; the input signals must be read in without errors and the output signals must be read out without error.
- The measured values of the signals K1 and K2 must be permanently compared within the tolerable tolerance period permissible for the application.
- The time of the output signal K2 must be constantly checked for plausibility. Static signals are to be regarded as internal errors.
- At cyclic intervals, an external test is to be triggered and its effect on the measuring signal must be recorded and evaluated. The time interval between two test cycles must not exceed the time required for the application
- An error message must cause the process to be transferred to a safe state.

4.5. Measured value conversion

The basic parameter of the system is the oxygen partial pressure. In systems with constant pressure, the oxygen partial pressure is proportional to the concentration in % by volume. For the processes used, it should be checked whether the oxygen partial pressure is the more relevant measured variable. The systems are adjusted to an oxygen concentration at an air pressure of 1013.25 hPa.

Thus, it is possible to convert the guide variable c[hPa] into the vol.% concentration c[vol.-%] as follows:

$$c[vol.-\%] = \frac{c[hPa]}{absolute\ pressure} * 100$$

If the measured value is interpreted as oxygen concentration $c_{measure}$[vol.-%], the pressure can be compensated as follows:

$$c_{pressure\ compensated}[vol.-\%] = \frac{1013{,}25}{pressure} * c_{measure}[vol.-\%]$$

4.5.1. Altitude correction

The air pressure decreases with rising altitude above sea level. The system displays the correct oxygen partial pressure. If the measured value is displayed as a Vol. % concentration, it will show less concentration with increasing altitude above sea level. The error can be calculated e.g. with the international altitude formula and via pressure compensation.

$$p_h = p_0 * \left(1 - \frac{0{,}0065 * h}{288{,}15}\right)^{5{,}255}$$

The height ‘h’ is expressed in [m].

4.5.2. Hypothesis for atmospheric fresh air

Why is the electrical calibrationdone at 20.7vol.-% oxygen?

In the literature, the oxygen concentration in atmospheric air is specified with 20,95vol.-%. This information is only valid for dry air. But in most of the cases there is humidity in the air.

Under the hypothesis of 21°C and a relative humidity of 40%r.H., there is only an oxygen concentration of 20,7vol.-% in the air.

4.6. Harmful substances

As the oxygen sensor contains zirconium dioxide and platinum, it can be destroyed by the following substances:

- Heavy metals
- Sulphuric compounds
- Silikone vapours
- Fluorine
- NH_3 (from 1000 ppm)
- Salts
- Long periods in a reducing atmosphere
- Phosphate ester
- Halogenated hydrocarbons (from 100 ppm)
- Chlorine
- SF_6
- Carbons

Dust, vibration, dirt, humidity, oil, grease, furnace cleaning agents, heavy heating oil, pyrolysis gases and silicone oxide shorten the life time of the oxygen sensor.
This list may be incomplete.

5. Maintenance and servicing

i	**IMPORTANT!** Service intervals: - Semi-annual measurement check - Five-year replacement cycle

i	**IMPORTANT!** Oxygen measuring systems are safety devices and must be repaired by the manufacturer only. Do not modify the oxygen measuring system and do not reconstruct it. Otherwise the oxygen measuring system might no longer measure the oxygen concentration reliably.

	DANGER! Mains voltage (230V, 50Hz). **Danger to life due to electric shock or burns.** Do not bring into contact with water. Before opening the oxygen measuring system, ensure that no dangerous voltage is applied. Electrical work should only be carried out by a qualified electrician. Only install in a voltage-free state.

CAUTION!
At ambient temperatures above 40°C, there is a risk of burning on the housing of the measuring system. Don’t touch without protection.

The oxygen measuring system and the connecting cable have to be checked at least every six months by qualified personnel (see chapter 1.4) and a servicing report has to be prepared. Always ensure that the interval between services meets safety requirements!
Check the measured values after each period of non-use or interruption of operation (see chapter 4.2). If the check of measured value has failed and the system cannot be calibrated, inform the manufacturer or dealer.
After each error message, carry out a measured value check, a calibration and, if possible, a function test (see chapter 3.4.3).
Make sure that the oxygen measurement system and its environment are always clean, visible and accessible. Above and beyond such measures, the oxygen measuring system is maintenance-free.

5.1. Change of probe protection tube

To replace the probe protection tube, the device must be switched off and cooled. The defective probe protection tube must be removed. Replace the O-ring and attach the new probe tube. Turning the tube during removal and insertion makes the process easier.

CAUTION!
The sensor element in the probe protection tube is hot (approx. 200°C). If the probe protection tube is damaged, there is a risk of burns and fire. Keep a safe distance between the measuring system and combustible material during installation.

CAUTION!
Depending on the defect of the probe protection tube, measures must be taken to prevent the operator from hurting, e.g. at sharp edges.

6. Decomissioning

Switch off the power supply. Please refer to chapter 3.2 for information on storage!

7. Product range / overview

7.1. Product-variant

Measuring range	Output	
0.1-25vol.-%	4-20mA	
	0-10V	

7.2. Spare-parts and accessories

Probe protection bar		
Calibration adapter		

7.3. Servicematerial

	Size	
Service case EF 0-1l/min		
Service case FF, 0.5l/min		
Gas Nitrogen 99.999vol.-% N2	34 l	
	58 l	
	110l	
Gas Oxygen 18.5vol.-% O2 in N2	34 l	
	58 l	
	110l	
Gas synthetic air Oxygen 20.9vol.-% O2 in N2	34 l	
	58 l	
	110l	
Gas Oxygen 23.5vol.-% O2 in N2	34 l	
	58 l	
	110l	

Other oxygen concentrations are available on request.

8. Packing and Transport

This device is a measuring instrument with sensitive electronic components. When returning it, please use the appropriate class of packaging according to the applicable regulations.

9. Disposal

Obsolete devices should be rendered unusable immediately and disposed of according to the relevant regulations. Please contact your local authority for information about disposal.

10. Appendix

10.1. Copyright

The copyright to these operating instructions is exclusively reserved

10.2. Guarantee

We, the manufacturer, grant a warranty for this device for a period of 6 months from initial operating, documented by a protocol of commissioning. Within this warranty period we will repair or replace the device free of charge if confirmed to be defective as to workmanship or material.

The warranty excludes: damages attributable to improper use, normal wastage (e.g. sensor element, sintered cap), and defects that only have a negligible influence on the device's value or suitability for use.

Liability for the functioning of the oxygen measuring systems shall pass at any rate to the owener or operator if the oxygen measuring system is improperly maintained or repaired, or if it is used different than for its intended propose. alpha redline accepts no liability for damage caused by non-observancing the above information.

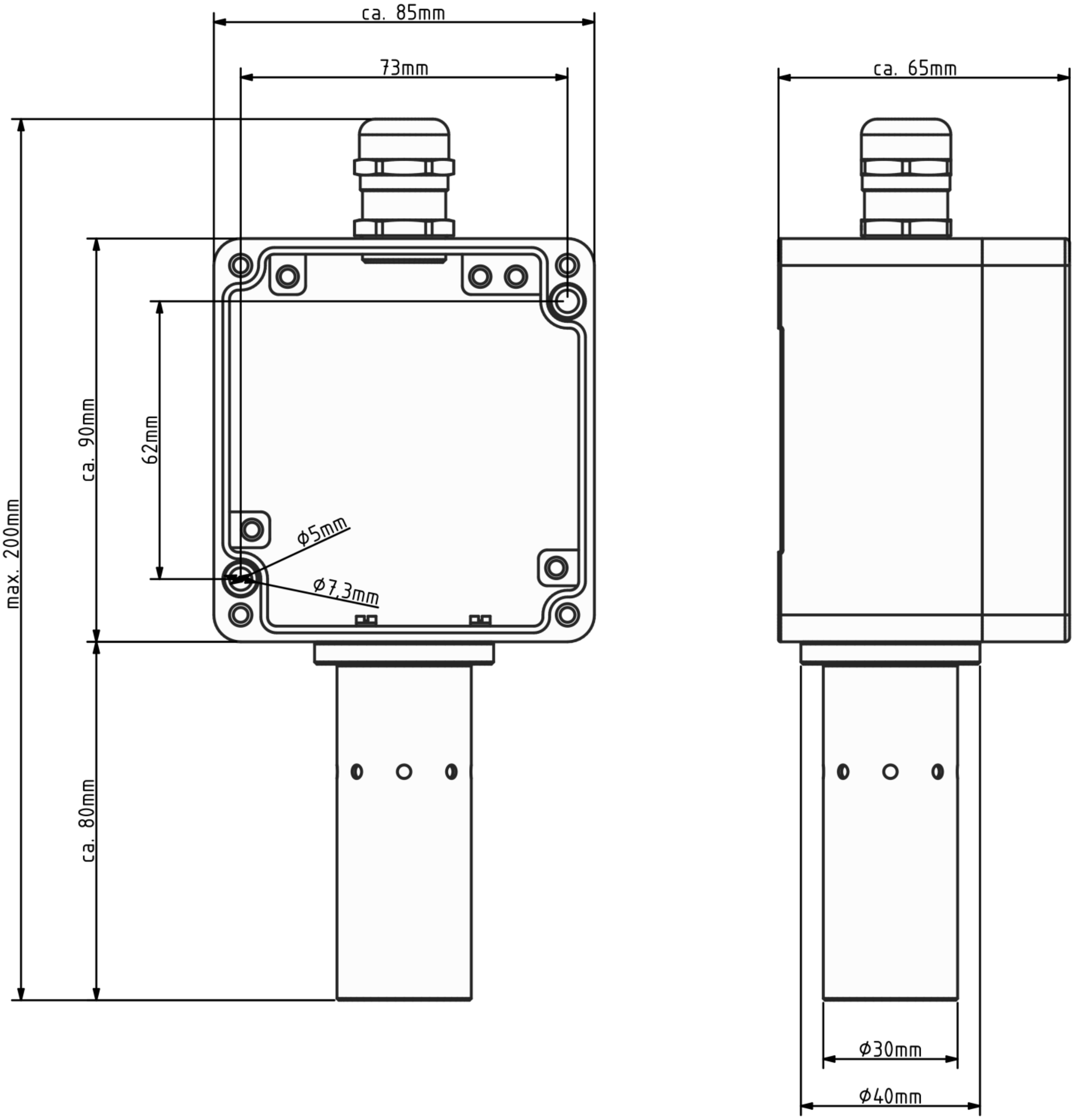
The warranty expires in the case that repairs are carried out by agents we have not authorised or if no original spare parts are used.

Claims under the warranty may be made in all countries where this device is sold by authorised dealers. In the case of any claim under the warranty, please return the device to us. The buyer shall bear the costs of transportation and the risk while the device is in transit. The execution of work under warranty does not affect the warranty period in any way.

The manufacturer accepts no liability for printing errors or any damage resulting therefrom.

The above information does not extend the conditions of warranty and liability contained in the Terms and Conditions of Sale and Delivery of alpha redline.

10.3. Dimensions



red line
Dr. Markus Kieninger
Vogelsangstr. 8
73666 Baltmannsweiler

Tel.: 07153 / 92 96 670
Tel.: 07153 / 92 96 671
Fax: 07153 / 94 50 25

www.alpha-redline.de
info@alpha-redline.de