ZIROX
Sensoren und Elektronik GmbH

Electrolysis Device SGM5-EL

FOR THE MODULATION OF DEFINED OXYGEN CONCENTRATIONS IN INERT GASES

OPERATION MANUAL

ZIROX Sensoren & Elektronik GmbH

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1 General information

1.1 Introduction

This operation manual describes design, function and operation of the Electrolysis Device SGM5-EL of the ZIROX GmbH.

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The manufacturer guarantees that this manual was written in accordance with the functional and technical features of the delivered SGM5-EL.

This manual is not subject to the amendment service. If the manufacturer modifies the SGM5-EL with the aim of making technical improvements, the user is responsible for inserting the additional or updated pages supplied.

Proper operation of the SGM5-EL can only be ensured if the contents of this manual are known. Therefore, all chapters of this manual must be read carefully prior to operating the SGM5-EL.

The values on the device display in this manual are examples or preset parameters of the manufacturer. Process-specific parameters must be set by the user.

Pages, charts and figures are numbered consecutively.

1.2 Copyright

1.3 Commonly used symbols

Symbol for imminent danger:

This symbol refers to imminent danger to persons' life and health.

In case of disregard fatal injuries may result.

Symbol for indirect danger:

This symbol indicates indirect danger.

The degree of the damage depends on the circumstances and the actions of the persons involved.


attention

In case of disregard, destruction or damage of the SGM5-EL, its single components or other material assets as well as minor injuries may result.

Symbol for proper handling:

NOTE

This symbol appears where the manual refers to the adherence to rules, instructions and proper operation.

In case of disregard, damage or destruction of the SGM5-EL or its single components may result.

2 Application fields

Designated use

One application field of electrolysis cells is the production of defined gas atmospheres with a low oxygen concentration (approx. 1ppm O_2 in N_2. With the SGM5-EL, a defined amount of oxygen can be electrolyzed into or out of the measuring gas (N_2, argon). The downstream analysis cell ensures that the oxygen concentration is measured accurately.

Another application field is the use for the solid electrolyte coulometry. In this case the e.m.f. of the analysis cell is kept constant as nominal value of an automatic control loop. The current at the electrolysis cell, resulting from it, is proportional to the oxygen exchange by the cell. With the measurement of I vs. t the oxygen exchange of arbitrary samples can be quantitatively determined.

Furthermore, it is possible to set a defined humidity in a gas mixture. Oxygen, for example, can be added to an argon hydrogen mixture. With the downstream analysis cell and a special evaluation electronics the dew point and so the humidity can be calculated.

Main fields of application

- Production of defined test gases e.g. for sensor tests
- Examination of the oxygen permeation of polymers (e.g. foils)
- Controlled outgassing of reactors
- System calibration and monitoring of TA systems (TG, DTA, TMA, DSC)
- Examination of the decomposition gases in thermal analysis

The introduction of explosive gas mixtures, halogens in high concentration, and sulphuric gases (e.g. SO_2) into the SGM5-EL is not permitted.

Functions

With the SGM5-EL

- the oxygen concentration in a measuring gas can be maintained
- the electrolysis current can be maintained
- the change of the oxygen concentration caused by probe reactions be quantified
- the oxygen output or uptake of a probe be quantified by interpretation of the I*t-diagram
- technical inert gases can be adjusted at the requested purity

The requirements and limit values provided in the "Technical Data" must be strictly observed.

Any other use is treated as non-authorized use.

3 Safety regulations

The following regulations for industrial safety provide basic information about potential danger during the operation of the SGM5-EL. Therefore, they must be observed and strictly followed by the responsible staff.

- A failure-free and functional operating of the device can only be guaranteed with knowledge of this manual. Therefore, all chapters of this manual must be read carefully before the installation and initiation of the device.
- The device is to be used for the functional operation only (see chapter 2).
  The device is to be installed, operated, and serviced by trained staff only.
- The SGM5-EL is to be connected to an isolated ground socket (Schuko-socket) with the supplied cable.

Explosive gas mixtures, halogens in high concentration, and sulphuric gases (e.g. SO_2) are not permitted to be measured by this SGM5-EL.

Due to the high operation temperature of the sensor, the SGM5-EL produces a lot of heat.
Make sure the device does not overheat because of covering.

Switch off and disconnect the device from the power supply before opening the housing cover of the SGM5-EL.

Condensate destroys the combination cell. If the device was used as a humidity generator, appropriate action to prevent the combination cell from condensate entry must be taken.

Special safety instructions for potential danger during certain working processes are given in relevant text passages.

4 Functional description

4.1 Measuring principle

Basic element of the SGM5-EL is the “combi cell”. An electrolysis cell and additionally an analysis cell are located on a ZrO_2 solid electrolyte pipe (general composition see chapter 6). Electrolysis and analysis cell are electrochemical cells with two platinum electrodes each. The combi cell separates the working substance from the ambient air.

If a current flows through the electrolysis cell, oxygen in chemically pure form will be transferred from or into the gas room based on *FARADAY*`s Law:

$$I \cdot t = n \cdot 4 \cdot F \qquad \textbf{(I)}$$

I - current in A
t - time in s
F - Faraday constant
n - amount of substance
4 - charge number

The driving force for the current flow through the cell is the resultant from the cell’s outside voltage u and the cell’s voltage $U_{eq.}$ If the sign of the resultant voltage corresponds to the sign of the cell voltage, oxygen flows through the solid electrolyte wall in the direction of the concentration gradient. If the sign of the resulting voltage reverses, oxygen is pumped against the concentration gradient.

For the pumping performance (in cm^3s^{-1}) the following applies:

$v\ (O_2) = 0{,}06336 \cdot I_{/A}$

The real oxygen concentration of the measuring gas is determined by the analysis cell. Its cell voltage U_{eq} in currentless condition depends on the oxygen partial pressure in the working substance and in the air as well as on the cell temperature. This correlation is based on the *NERNST* Law:

$$U = \frac{RT}{4F} \ln \frac{p_{O2,\,meas.gas}}{p_{O2,\,air}} \qquad \textbf{(II)}$$

U - cell voltage in V
R - molar gas constant
T - measuring temperature in K
F - Faraday constant

$p_{O2,air}$ – oxygen partial pressure at the reference electrode in dry air in Pa

$p_{O2,meas.gas}$ – oxygen partial pressure at the measuring electrode in Pa.

Based on the assumption that the total pressures of the gases are almost the same at both electrodes (in this case the volume concentrations may be used in the calculation instead of the partial pressures) and replacing the parameters by numbers in equation (**I**) the following equation applies:

$$\varphi_{O_2} = 20.64 \cdot e^{(-46{,}42 \cdot \frac{U}{T})} \qquad \textbf{(III)}$$

U - potential difference in mV
T - measuring temperature in K
20.64 - oxygen concentration in air with a relative humidity of 50% in vol%.
φ_{O2} - oxygen concentration in the measured gas in vol%

4.2 Measuring conditions

4.2.1 General recommendations

The oxygen may be in free or bound form inside the measuring gas[1].

Thereby, the following dependencies are valid:

$U \sim T$ – for free oxygen

$U \sim \frac{1}{T}$ – for bound oxygen

The equation **(III)** for calculating the oxygen concentration is valid for measured gases with free oxygen as well as for reducing gas mixtures in which oxygen only exists in bound form (e.g. in H_2/H_2O- or CO/CO_2-mixtures).

Reducing gas mixtures

In reducing gas mixtures, the oxygen partial pressure is inversely proportional to the temperature. For converting the measured value at the measuring temperature into other temperatures special thermodynamic equations are required.

[1] Different conditions of oxygen in the measuring gas must be distinguished:

Free oxygen: Oxygen molecules in the gas are independent without a bond to other gas components (inert gases such as N_2 or Ar).

Bound oxygen: Free oxygen molecules do not exist in the gas, only in bound form e.g. as water vapor. Higher temperatures cause a dissociation and oxygen molecules are available. Since the dissociation degree increases with the temperature, the measurement result depends on the temperature.

Possibly, free oxygen can react with potential burnable gases at the hot platinum electrode. The result can be a reducing gas.

4.2.2 Gas flow quantity

NOTE

For exact measurements a flow rate between 5 and 10 l/h of the measuring gases must be ensured (see also chap. 8.1.2)

Contamination effects of the gas tubes (leaks, permeability, desorption) may cause falsified measuring result if the flow rate is too low.

Asymmetric cooling of the sensor electrodes may cause falsified measuring results if the flow rate is too high.

4.2.3 Accuracy of the measurement

The SGM5-EL can be used as an electrolysis device *and* as an oxygen measuring device. For the measuring of oxygen the manufacturer guarantees a measuring error of less than 3% (relative error) only at oxygen concentrations within a range of $20.64*10^4$ ... 10 ppm[1]. For measurements at oxygen concentrations of 10 ... 0.5 ppm the relative error is less than 5% if the gas inlet tube has no leakages or permeability.

During the electrolysis the limit values can only be reached if the measuring gas is tuned to the measuring problem (e.g. It is not possible to get oxygen concentrations in the “per-cent-area” from pure nitrogen).

For measurements of oxygen concentrations less than 10 ppm the following aspects must be taken into account during evaluation:

- composition of the measuring gas (e.g. presence of burning gases);
- specific characteristics of the production process (e.g. material used);
- temperature of the measuring gas.

NOTE

To reduce the measuring error in low oxygen concentrations, the following conditions must be provided:

- All gas inlet and outlet pipes must be free of leakages.
- For measurements of oxygen concentrations of less than 100 ppm, the use of steel pipes is necessary.
- If the measuring gas contains reducing components (e.g. alcohol), the concentration of free oxygen cannot be determined correctly as chemical reactions occur at the electrode. In such cases the measuring gas should be filtered by an active carbon filter before entering the SGM5-EL. (see Appendix)

[1] Throughout the manual the measuring unit "ppm" is defined as "vol.-ppm".

5 Technical data

5.1 Characteristics

Description	Electrolysis device (SGM5-EL)
Application	Modulation of oxygen concentrations in inert gases
Measuring range	$20.64*10^4$... 0.5 ppm, (20.64... $0.5*10^{-4}$ vol.-%) Measuring possible up to 10^{-20} ppm, see chapter 4.2
Accuracy at normal pressure	Relative error < 3% in the range of $20.64*10^4$... 10 ppm Relative error < 5% in the range of 10 ... 0.5 ppm
Gas flow quantity	5 ... 10 l/h for the given accuracy
Max. permitted pressure of the measuring gas	100 mbar overpressure vs. ambient pressure
Max. permitted temperature of the measured gas	80°C at the gas inlet
Pressure loss in the SGM5-EL	Approx. 1 kPa (100 mm water column) at 10 l/h

5.2 Mechanical data / ambient conditions

Dimensions	Controlling device: Combi cell:	320×240×90 262x119x119
Weight	Controlling device: Combi cell:	2.5 kg 1.5 kg
Gas connection	3 mm Swagelok®	
Ambient temperature/humidity	10…40 °C, 95 % rH at 20 °C	
Storage temperature/humidity	-20…60 ° C, 95 % rH at 20 °C	

5.3 Electrical data

Protection degree	Controlling device: Combi cell:	IP 30 IP20
Power supply		
Voltage	110 ⋯ 230 V/50 ⋯ 60 Hz	
Power consumption	50 VA	
Keypad and display		
Keypad	Membrane keypad with 6 keys	
Text display	LCD dot-matrix	

5.4 Interface data

Serial interface RS-232

Transfer rate ..... max. 19200 Baud, adjustable
Stop bits 1
Data bits 8
Parity ..... none
Handshake ..... none

Interface commands

All characters are ASCII - characters.

Each transfer is completed with 'CR' (*CR = carriage return*).

Command	Reply (response)	Description
M1*CR*	M1x.xxE+xx*CR*	Measuring value channel 1
M2*CR*	M2x.xxE+xx*CR*	Measuring value channel 2 (Electrolysis current [mA]
A1*CR*	A1x.xx*CR*	Voltage of the analysis cell [mV]
A2*CR*	A2x.x*CR*	Temperature of the analysis cell [°C]

u0*CR*	u0 x.x*CR*	Voltage of the analysis cell [mV]
u1*CR*	u1 x.x*CR*	Temperature of the analysis cell [mV]
u2*CR*		Not used
u3*CR*		Not used
u4*CR*	u4 x.xxxE+xx*CR*	Measuring value channel 1
u5*CR*	u4 x.xxxE+xx*CR*	Measuring value channel 2 (electrolysis current [mA])
u6*CR*	u6 x.x x.x x.xxxxE+xx*CR*	Vz [mV], Tz [°C], electrolysis current [mA]

Modulation of the control parameter

r00*CR*	R00 x.xxxxE+xx*CR*	Read command variable (values are read from the internal memory)
R00 x.xxxxE+xx*CR*	R00 x.xxxxE+xx*CR*	Set command variable 0 - OFF 1 – Cell voltage [mV] 2 – Electrolysis current [mA] 3 – Oxygen concentration [ppm]
r01*CR*	R01 x.xxxxE+xx*CR*	Read setpoint
R01 x.xxxxE+xx*CR*	R01 x.xxxxE+xx*CR*	Set setpoint
r02*CR*	R02 x.xxxxE+xx*CR*	Read proportional value
R02 x.xxxxE+xx*CR*	R02 x.xxxxE+xx*CR*	Set proportional value
r03*CR*	R03 x.xxxxE+xx*CR*	Read reset time
R03 x.xxxxE+xx*CR*	R03 x.xxxxE+xx*CR*	Set reset time
r04*CR*	R04 x.xxxxE+xx*CR*	Read rate time
R04 x.xxxxE+xx*CR*	R04 x.xxxxE+xx*CR*	Set rate time
R!R!	R!	Save values

Error code	Meaning
error0	Transcription error
error11	Measuring temperature too low
error16	Thermocouple defective
Error20	System error
Error99	No connection to the SGM5-EL

Pin assignment of the socket SUB-D 9-pol. F *Pin assignment RS 232*

Pin No.	Marking
2	TxD
3	RxD
5	GNDA

Analog output	0/4 ... 20 mA, adjustable, alternatively 0 ⋯ 5 V or 0 ⋯ 10 V (on request)
Alarm indication	three potential free contacts (Changer), max. 60 V DC, 1 A, 30 W or 125 V AC, 1A, 62 VA

Pin assignment of the socket analog output SUB-D 15-pol. F

Pin No.	**Marking**	**Legend**
1	out1+	Analog output 1
2	out1-	Analog output 1
3	out2+	Analog output 2
4	out2-	Analog output 2
5		
6		
7	AL AK	Alarm relay working contact
8	AL MK	Alarm relay
9	AL RK	Alarm relay break contact
10	GW1 AK	Relay limit value 1
11	GW1 MK	
12	GW1 RK	
13	GW2 AK	Relay limit value 2
14	GW2 MK	
15	GW2 RK	

6 Composition of the SGM5-EL

6.1 General composition

The SGM5-EL is composed of the control unit and the combicell. The general composition and evaluation unit are shown in figure 1. The combi cell consists of electrolysis cell and analysis cell (figure 2).

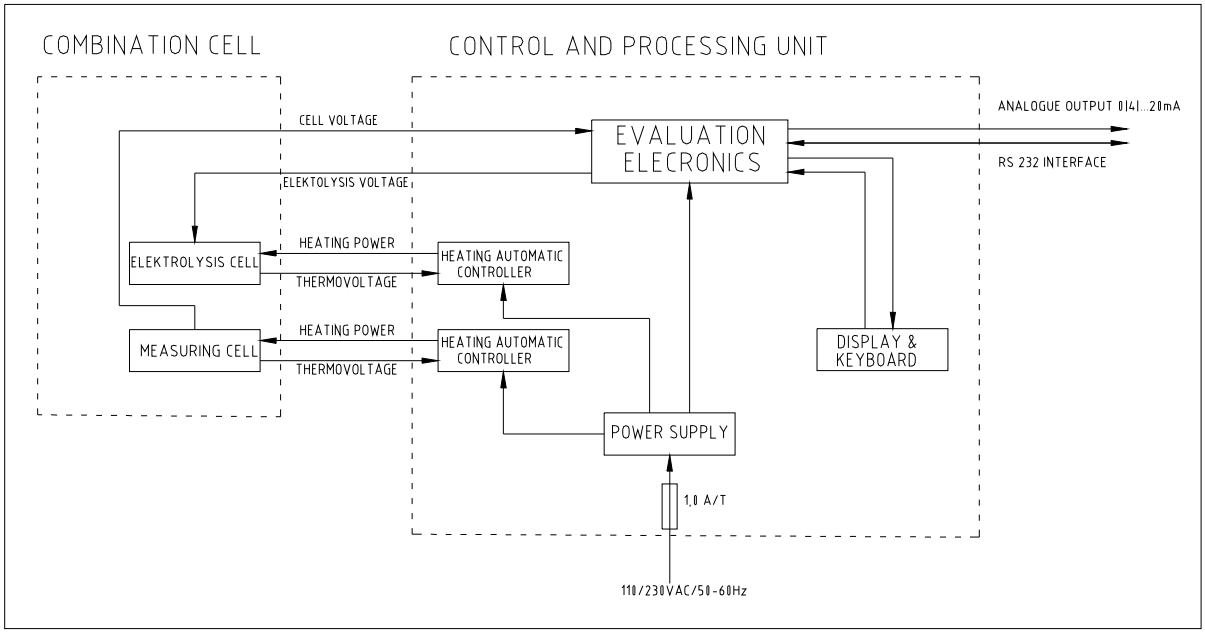
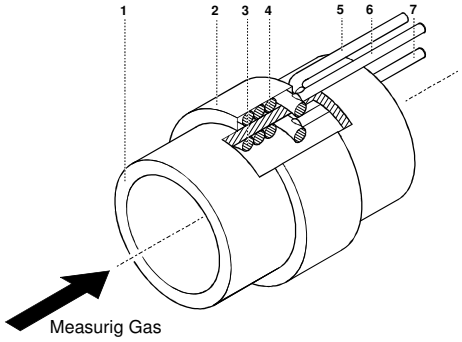


Fig. 1: *Circuit diagram of the SGM5-EL*



1 Ceramic tube
2 Ceramic cover of the reference electrode
3 Measuring electrode
4 Reference electrode
5 Thermocouple
6 Reference electrode connection
7 Measuring electrode connection

Fig 2: *General composition of electrolysis and analysis cell*

Measuring cell (sensor)

The electrolysis cell and the analysis cell consist of a tube made of zirconium dioxide (2/1) with two platinum wire electrode. Inside the tube the measuring electrode (2/3) is placed. The reference electrode (2/4) outside the tube has a constant electrode potential. The measuring gas flows through the ceramic tube. The electrodes and the ceramic tube form a galvanic cell (solid electrolyte cell).

Sensor heater

In order to gain a higher oxide ion conductivity of the zirconium dioxide tube, the sensor is heated up to 750°C. This also prevents interfering reactions with combustible components of the measuring gas at the electrode due to chemical unbalances. A thermocouple (2/5) inside the measuring cell determines the actual electrode temperature. A heater control ensures a constant temperature.

The heated combi cell produces lost heat. Make sure the device does not overheat because of covering.

The measuring gas is pressed into the combi cell with low overpressure. For the regulation of the gas flow a gas mixture device, needle valve or pressure reducer can be used.

6.2 Construction of the control unit

6.2.1 Power supply

The SGM5-EL is connected with the power supply system with the supplied cord set.

Operating position and inclination adjustment

The SGM5-EL is designed as a desktop device. It is operated in horizontal position with a maximum angle of inclination of 30°. The angle of inclination of the SGM5-EL can be altered by pulling out the two attachment points of the carrying handle between 0° and 30°. When the attachment points are released, the carrying handle engages in the chosen position.

6.2.2 Front

Display and control elements are located on the front of the control unit.

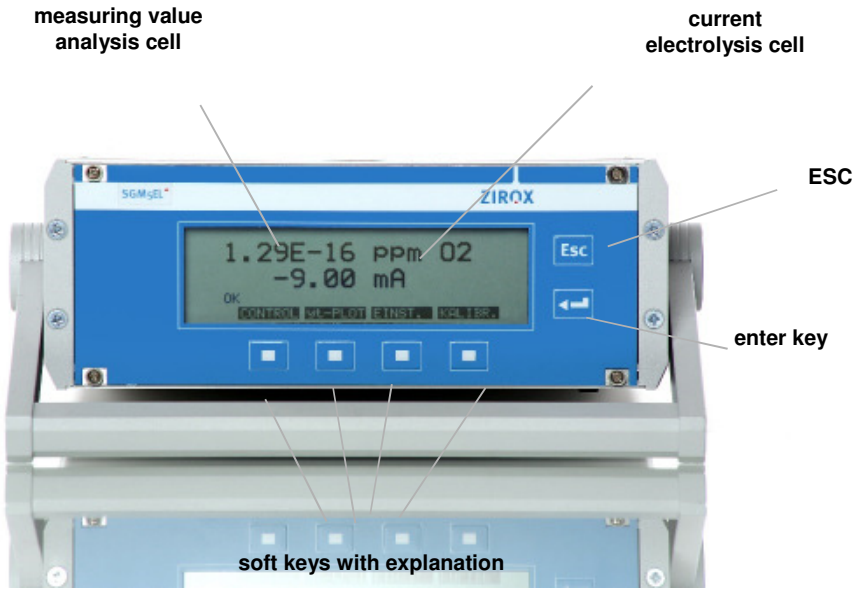


Fig 3: *Front of the control unit*

6.2.3 Rear

All connections and the power switch are on the rear of the SGM5-EL.

Fig 4: *Rear of the control unit*

6.2.4 Combi cell

The combi cell is connected with the control unit with a 12pol cable. The gas supply is connected via screw connections at the measuring head.

7 Installation and initiation

7.1 Installation conditions

NOTE

The protective gas monitor must be set up in a dry and mainly dust-free place.

- A socket, preferably as a separate electrical circuit, must be available in immediate proximity of the installation place, protected with a 10 A fuse.
- No heat sources or appliances which produce strong magnetic fields (e.g. electric motors, transformers) should be put in the proximity of the installation place.
- The SGM5-EL operates in horizontal position.

A vertical placement may cause damage by heat accumulation and is not permitted.

A liquid entry can lead to severe damage or to the complete destruction of the device. Do not place any items filled with liquids in immediate proximity of the SGM5-EL!

7.2 Set-up of operating state

A temperature compensation is required after the transportation of the SGM5-EL from cold surroundings to a site with higher ambient temperature or humidity**. A waiting time of about 2 hours** before switching-on must be considered.

NOTE

1. Install the SGM5-EL in your favored place (see chapter 7.1).
2. Connect point of measurement and places of gas inlet and outlet of the SGM5-EL. Pay attention to leak-tightness. For a fast measuring result the dead volume of the gas lines must be kept low.
3. If a pressure limit is required, install a needle valve directly in front of the gas inlet (available from manufacturer of the SGM5-EL).

Material of the connecting tubes

On long transport routes and at unfavorable temperatures the material of the connecting tubes must rule out any oxygen permeability. The manufacturer recommends the following materials in dependence on the measuring conditions:

Oxygen concentration of < 100 ppm ..... Stainless steel tube.

Silicone can cause measuring inaccuracies because of its oxygen permeability. Therefore, the manufacturer advises against use.

If the amount of water vapor in the measuring gas is likely to cause a condensation of water in a cold gas pipe, a water trap must be installed in front of the gas inlet. (The penetration of water into the hot measuring cell can destroy it and therefore must be absolutely prevented.)

4. If you want to install an external flow meter, you have to install it **behind** the gas outlet (where potential leaks do not have an influence on the measuring result).
5. Connect the SGM5-EL with the power supply.

NOTE

The measuring gas can also flow through the cold combi cell.

For using Swagelok®-fittings please note the manufacturer's advice in the appendix of this manual!

8 Operation and parametrization

8.1 Operation

8.1.1 Switch-on and measurement indication

When the SGM5-EL is in operating state and all lines are connected according to chapter 7.2, it can be switched on. The combi cell reaches its operating temperature of 750 °C after approx. 10 minutes. The current measuring value is displayed but only reaches the indicated error limits after an hour when the thermal conditions in the measuring cell are even.

After switch-on the SGM5-EL is in display mode. On the display the programmed measuring value for output 1 is shown (normally the oxygen concentration) digitally according to the chosen dimension(vol% or ppm) or as an analog bar. In the second line of the display on the right side either the temperature of the measuring cell in °C or the cell voltage in mV is shown.

Underneath a warning or error code could be indicated.

NOTE

If the control parameter is the electrolysis current, the electrolysis voltage is limited (1.5V for electrolysis cell protection)!
If there is no constant electrolysis current, the necessary electrolysis voltage might not be supplied by the device!

8.1.2 Gas flow adjustment

NOTE

For exact measurings a flow rate of 5 to 10 l/h (40…50 scale parts of external flow meter) has to be ensured. For measurings at equal pressure the flow rate is realized by an internal pump.

At excess pressure of the measuring gas the manufacturer recommends the installation of a high-quality needle valve. Appropriate needle valves can be delivered by the manufacturer of the SGM5-EL. For higher pressures of the measuring gas an **additional** pressure regulator is recommended which adjusts a pressure of approx. 100 kPa (1 bar) **excess pressure.**

8.1.3 Data monitoring

In the SGM5-EL two limit values can be programmed which provide messages over relay exits. The relays are opened in the active condition. This condition is displayed for active limit values on the left on the second line. The signaling is delayed. The response time can be adjusted for the data monitoring (limit value delay time) between 1 second and 99 seconds.

8.1.4 Status and error messages

Self-check of the SGM5-EL

During the measuring the functions of the measuring cell are monitored. In case of faults and/or error, messages are displayed. The relay output is activated simultaneously.

The following status and error messages can appear:

Message	Condition	Remark
LIMIT 1		
LIMIT 2		
LIMIT 1/2		
RANGE <<<		[1]
RANGE >>>		
WARM UP	< 740° and <15 min	[2]
LOW TEMPERATURE	< 740° and >15 min	
ERROR THERMOCOP.		[3]
SELF TEST FAILED		

The signalling units react according to footnotes 1-3.

8.2 Adjustable parameters

The following menus are available with the keys underneath the display (The current meaning of the keys is displayed). With ↵ the parameter can be activated for adjusting, changed with the appropriate key and finally confirmed with ↵ .

Key assignment of the main display

CONTROL	XY-PLOT	SETTING.	CALIBR.

[1] Warnings, only alarm relay active

[2] Slight error, alarm relay active, current signal zero if prepared for O_2

[3] Serious error, alarm relay active and current signal zero

A. Control

CONTROL PARAMETER		
CONTROL:	pO_2 [ppm]	also OFF, Uz/mV ,Ie/mA
SETPOINT:	200	input value
Kpr:	0.04	
Tn:	0.3	
Tv:	0.01	
▼ ▲	SAVE. RETURN	

B. Strip chart

XY-Plot → SET

XY-Plot		
TRACE	ppm O_2	also Ie/mA
Yaxis-min:	0 ppm	
Yaxis-max:	300000 ppm	
Xaxis:	3 min	
▼ ▲	SAVE RETURN	

C. Settings

SETTINGS
1 GENERAL
2 LIMITS
3 OUTPUT 1
4 OUTPUT 2
1 2 3 4

C.1. General

GENERAL		
USER CODE:	0000	
NEW USER CODE:	0000	
LANGUAGE:	ENGLISH	*English,German*
BAUD RATE:	19200	*4800,9600*
▼	▲ ◀ ▶	

C.2. Limits

LIMIT VALUES		
LIMIT VALUE 1:	> 250000 ppm	*1...250000ppm, < or >*
LIMIT VALUE 2:	> 250000 ppm	*1...250000ppm, < or >*
DELAY TIME:	1 sec	*1...60s*
▼ ▲	SAVE RETURN	

C.3. OUTPUT 1 (resp. OUTPUT 2)

OUTPUT 1		
VALUE:	O_2	*O_2[ppm], Vz,; (Ie out. 2)*
RANGE:	4 – 20 mA	*0-20 mA or 4-20mA resp.*
		0-5Vor 0-10V
RANGE ZERO POINT:	0 ppm	*adjustable to 210000 (for optimal solution)*
RANGE END MARK:	1000 ppm	*adjustable to 210000*
AVARAGE FACTOR:	1 sec	*1-30 s*
▼ ▲	SAVE RETURN	

D. Calibration

CALIBRATION	206400 ppm
ZERO GAS:	206400 ppm
CALIBR. ZERO POINT:	OK (5.6)
SPAN GAS:	1 ppm
CALIBR. SPAN GAS:	OK (1.00)
▼ ▲	START/SAVE RETURN

8.3 Calibration

For measurements with high accuracy requirements a calibration is highly recommended (The high stability of the combi cell requires one check-up per year only!).

The device must be in operating state for a minimum of two hours before the calibration!

8.3.1 Zero calibration

The zero calibration serves the balance of the offset voltage of the ZrO2-sensor. The offset is caused by the construction (when the electrode has a disadvantageous position in the heating field) and can occur due to aging of the sensor.

Before calibration, the sensor is flushed with ambient air. The gas flow is set by internal or external pump at the value which is used for measuring the measuring gas.

With the zero calibration, the working point in ambient air is calibrated with 20.64 vol.% O2.

8.3.2 Span gas calibration

Certified test gas (oxygen concentration near future measuring conditions) must flow through the device.

The stability of the measuring value is checked during the calibration. The real calibration process starts as soon as the signal produced by the test gas is stable. Therefore, the duration of the calibration process can vary (variation under 1 % in 4 seconds).

If the stability is not given, the calibration is stopped after 60 seconds.

Furthermore, the deviation of measuring value from set value is evaluated. At zero point calibration +/- 20 mV (cell voltage), at span gas calibration +/- 20 % of measuring value (cell voltage) are allowed.

For the adjustment the following equation applies: Vcellkorr=(Vz+A)*B

With Vz=measured cell voltage, A=cell voltage at zero point, B=factor for final value adjustment.

Report of the calibration status:

OK (1.5)	Last calibration OK (calibration value)
WAIT ! 5	Calibration running
BREAK	Cancel by pressing key
TIME OUT	Stability not reached within 30 sec
OUT OF RANGE	Range exceeded
FAILED	Device error

8.4 Fault clearance

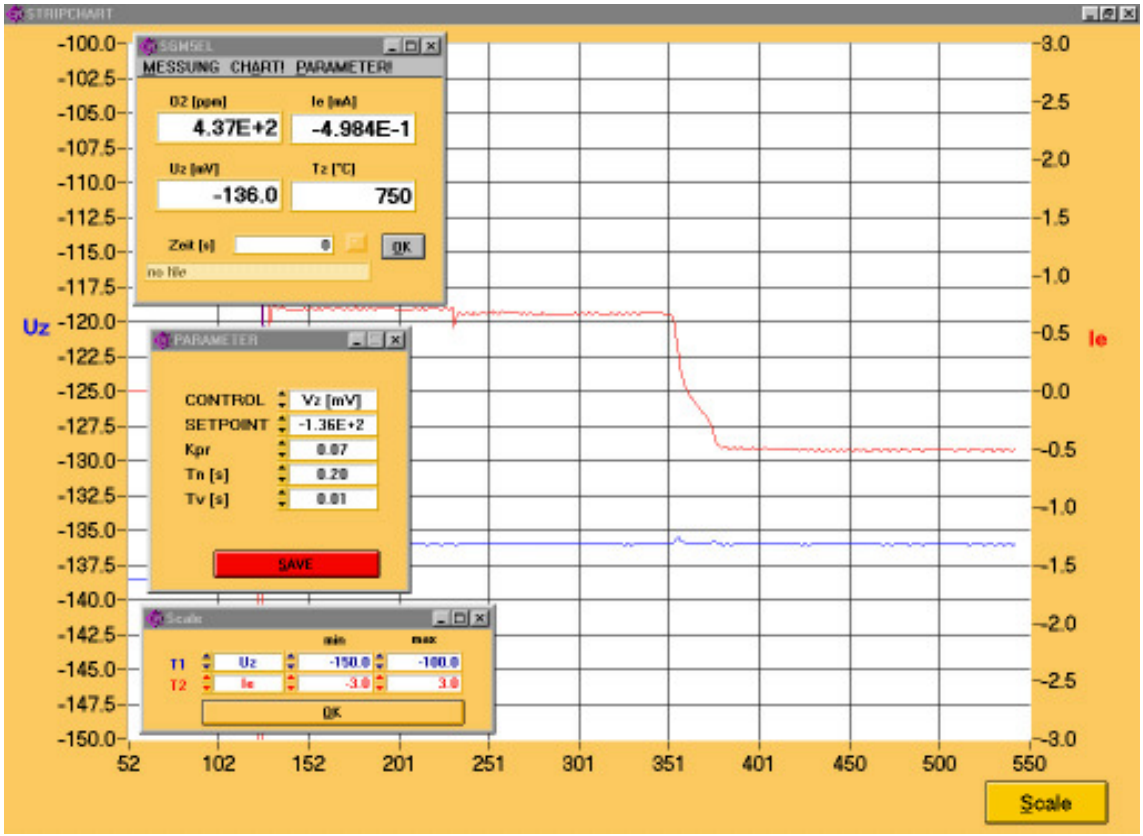
Disturbance	**Cause**	**Clearance**
Display off	SGM off	Switch on SGM
	No current supply	Check current supply and cord set
	Equipment fuse tripped	Change equipment fuse
Relatively high measuring value, although a low value for the oxygen concentration is expected	Gas flow too low	Increase flow
Measurement is dependent on the throughput (the smaller the flow, the higher the value or vice versa)	Leaks in the measuring gas supply	Check measuring gas supply and fittings
Measurement is significantly lower than expected	Reacting components (at high temperatures with oxygen) in the measuring gas (e.g. hydrocarbons)	Use carbon filter or check existing filters for saturation
Warning: “Warm up”	Measuring cell has not reached operating temperature yet	Wait for 5 minutes
	Fuse for sensor heater tripped	Switch off Check again after switching on Consult service if necessary
	Heater or regulator defective	Consult service
Warning: Error thermocouple	Thermocouple defective	Consult service
Warning: System error	Measuring cell probably defective	Consult service
Warning: Range	Oxygen concentration so low that electronics is overdriven	Measuring gas might contain combustible components which react with the oxygen
Electrolysis current too low	Electrodes defective	Send SGM5-EL to manufacturer
Cell voltage of analysis cell too low (lower than expected)	Leaks or electrodes of the analysis cell defective	Check gas connections Send SGM5-EL to manufacturer if necessary
Expected electrolysis current not reached	Capacity of electrolysis cell reached	Adapt measuring gas to measuring conditions

8.5 Operation via PC

The most important settings of the SGM5-EL can also be executed with a software (optional) via PC.

After starting the program, the COM interface must be entered which connects the equipment with the computer. In the following window the cell voltage of the analysis cell and the resulting O_2-concentration in the measuring gas, the temperature of the electrolysis cell and the parameter which controls the electrolysis cell are displayed. The favored control parameter (O_2-concentration, cell voltage or electrolysis current) is to be set under the menu item PARAMETER. Additionally, a diagram can be opened during the measurement which displays the favored parameter against time.

The process of the measurement can be saved. Click on START under the menu item MEASUREMENT (MEASUR.) and start a data file. If data storage is not needed, press key for abort.



9 Maintenance, overhaul and storage

9.1 General notes

The electronics and the combi cell are maintenance-free.

In case of defects in combi cell or thermocouple, send the SGM5-EL to the manufacturer for an overhaul.

If not used, the SGM5-EL has to be stored in a dry, dust-free room in the original packing (if possible). *storage*

9.2 Replace the equipment fuse

Before replacing the equipment fuse, turn off the SGM5-EL and separate it from the power supply system.


danger

1 Open the cover plate in the input supply unit with a flat screwdriver or the like.

2 Remove fuse, examine and replace it by an identical type if necessary (1 A/T).

3 Put the cover plate into place and engage it by pushing slightly.

10 Appendix

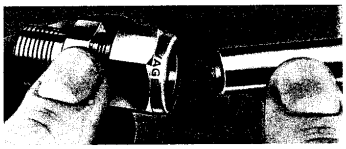
10.1 Mounting instructions for Swagelok®-fittings

Installation Instructions

Swagelok tube fittings 1 in. or 25 mm and Under

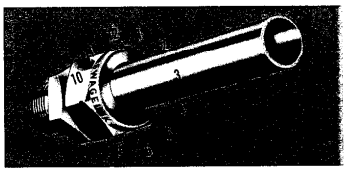
Swagelok tube fittings come to you completely assembled, finger-tight and are ready for immediate use. Disassembly before use is unnecessary and can result in dirt or foreign material getting into fitting and causing leaks.

Swagelok tube fittings are installed in three (3) easy steps:



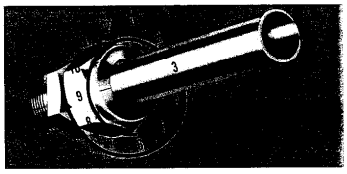
Step 1

Simply insert the tubing into the Swagelok tube fitting. ***Make sure that the tubing rests firmly on the shoulder of the fitting and that the nut is finger-tight.***



Step 2

Before tightening the Swagelok nut, scribe the nut at the 6 o'clock position.



Step 3

Hold the fitting body steady with a backup wrench and tighten the nut 1 1/4 turns.① Watch the scribe mark, make one complete revolution and continue to the 9 o'clock position.

By scribing the nut at the 6 o'clock position as it appears to you, there will be no doubt as to the starting position. When the nut is tightened 1 1/4 turns to the 9 o'clock position, you can easily see that the fitting has been properly tightened.

Use of the gap inspection gage (1 1/4 turns from finger-tight) ensures sufficient pull-up.

High Pressure Applications or High-Safety-Factor Systems

Due to variations in tubing diameters, a common starting point is desirable. Using a wrench, tighten the nut to SNUG position. Snug is determined by tightening the nut until the tubing will not rotate freely (by hand) in the fitting. (If tube rotation is not possible, tighten the nut approximately 1/8 turn from the finger-tight position.) At this point, scribe the nut at the 6 o'clock position and tighten the nut 1 1/4 turns.① The fitting will now hold pressures well above the rated working pressure of the tubing.

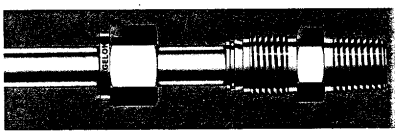
Note: A Swagelok Hydraulic Swaging Unit must be used for assembly of Swagelok tube fittings onto 1 1/4, 1 1/2, 2 in., 28, 30, 32, and 38 mm outside diameter steel and stainless steel tubing (see page 55).

①For 1/16, 1/8, 3/16 in., 2, 3, and 4 mm size tube fittings, only 3/4 turn from finger-tight is necessary.

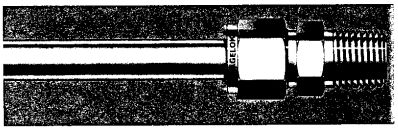
Retightening Instructions

Connections can be disconnected and retightened many times.
The same reliable leak-proof seal can be obtained every time the connection is remade.

1. Fitting shown in the disconnected position.



2. Insert tubing with preswaged ferrules into fitting body until front ferrule seats.



3. Tighten nut by hand. Rotate nut to the original position with a wrench. *An increase in resistance will be encountered at the original position.* Then tighten slightly with the wrench. Smaller tube sizes will take less tightening to reach the original position, while larger tube sizes will require more tightening. The wall thickness will also have an effect on tightening.

10.2 Declaration of conformity

EG Conformity Declaration

Document- Nr.: **17** March **23rd, 2015**

Manufacturer: **Zirox Sensoren & Elektronik GmbH**

Address: **Am Koppelberg 21**
D - 17489 Greifswald
Germany

Product designation: SGM5-EL

According to the EC directive about the electromagnetic compatibility **89/336/EWG** we declare under our sole responsibility that this product is in conformity with the following standards or other normative documents:

Harmonized standards:

Number:	Text:	Date of issue:
DIN EN 61000-6-2	Electromagnetic compatibility (EMV) Part 6-2: Generic standards for industrial environment	08.2002
DIN EN 61000-6-3	Conducted emission Radiated emission	08.2002
DIN EN 50270	Electromagnetic compatibility (EMV) Electrical devices for detection and measurement of combustible gases, toxic gases and oxygen	01.2000

This declaration certifies conformance with the above mentioned directives. Affirmation of attributes in a legal sense is not included. Safety declarations and installation instruction given in the product documentation have tob e considered.

Issuer: **Zirox Sensoren & Elektronik GmbH**

Place, date: Greifswald .....

Signature: .....

10.3 Warranty conditions

ZIROX Sensoren & Elektronik GmbH warrants that the products manufactured and sold are free from manufacturing and material defects at the time of dispatch. In case of defects and faults within 12 months (probe) and 24 months (electronics assembly) respectively after dispatch, ZIROX will clear faults at its own option by repair or replacement. The purchaser must give prompt written notice to ZIROX. The purchaser is not entitled to claim other legal remedies based on this warranty.

ZIROX does not warrant supplied products which are subject to normal wear and tear (e.g. reference gas pump).

Corrosive gases and solid particles may cause damage and require repair or replacement due to normal wear and tear.

The contact of the products with explosive gas compounds, halogens in high concentrations and sulphuric gases (e.g. SO_2) is not permitted.

The contact of the products with siliconic or phosphoric compounds is not permitted either.

A connection of ZIROX and non-ZIROX products voids any warranty claims.

Warranty and warranty claims are only accepted if they are in accordance with the "General Sales and Delivery Conditions" of the manufacturer.

Warranty and liability claims for damage to persons and/or property are void if they are subject to the following:

- Normal wear and tear
- Improper use of the product
- Disregard of the manual's instructions
- Improper installation, initiation, operation and maintenance of the product
- Operation of the product without protective measures
- Unauthorized functional and technical modification of the product
- Dismantling of parts as well as installation of spare parts or additional units which are not delivered or permitted by the manufacturer
- Improper repairs or faulty operation
- External impact
- Acts of God

Attention: When installing the equipment, the customer must ensure that all necessary supply lines are connected and the operating temperature of the probe is reached. Experience has shown that products installed but not in use may be damaged by the process or by external influence. ZIROX will not accept any responsibility for such damage.