

User's Manual



Gas Detector

ProGas / Sigma ProGas

Product code: PW-017-X



We design, manufacture, implement and support:

Systems for Monitoring, Detection and Reduction of gas hazards

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Remarks and reservations

- Connection and operation of the device is allowed only after reading and understanding the contents of this document. Keep User's Manual with the device for future use.
- The manufacturer bears no responsibility for errors, damages and failures caused by improper selection of devices and cables, improper installation or failure to understand the contents of this document.
- Unauthorised repairs and modifications of the device are not allowed. The manufacturer bears no responsibility for the results of such interventions.
- Excessive mechanical, electrical or environmental exposure may result in damage to the device.
- Use of damaged or incomplete devices is not allowed.
- The design of the gas detection system for a protected facility may involve other requirements throughout all stages of the product life.
- It is unacceptable to use parts other than those listed in Table 9.

How to use this manual?

The following symbols of optical indicators status are used throughout the document:

Symbol	Interpretation			
	Optical indicator on			
	ptical indicator flashing			
O	Optical indicator off			
O	Optical indicator status not determined (depends on other factors)			

Table 1: Optical indicators status notation

Important parts of the text are marked as follows:



Pay special attention to information given in these fields.

User's Manual consists of main text and appendices. Appendices are independent documents and can exist without User's Manual. Appendices have their own page numbering independent of User's Manual page numbering. These documents can also have their own tables of contents. All documents included in the User's Manual are marked in the bottom right corner with their name (symbol) and revision (issue number).



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1 Preliminary information

1.1 Safety

When performing repair and construction works in rooms where Gas Detectors are installed, one must keep in mind that the detectors need to be properly secured and the workers must be instructed that they are responsible for any damage to them. This is important because possible mechanical damage is not covered by the warranty and may even lead to its loss. The user is responsible for all consequences. Please pay particular attention to:

- repair crews
 - · not covering the detectors with paint,
 - switching off the system completely for the time of painting with any paint, with the exception of water-based paints, because high concentration of solvents in the air may lead to an irreversible loss of the sensor's properties,
- other contractors
 - make sure that they do not cut or damage the insulation of the cables in the system,
 - no element of the system may be used as a support for tools or for leaning against.



Do not install gas detector in places exposed to direct impact of water and sunlight. Do not expose the gas detector to vapors of paint, lacquers, solvents and alcohols. Do not clean the gas detector using chemical agents. Secure or dismantle the gas detector for the duration of repairs. Do not paint over the gas detector.



In the event of damage, the Gas Detector must be switched off, its connecting cables must be secured, and the technical service must be contacted.



The user must not test the detector by tripping it with gas of unknown content and concentration, e.g. lighter gas. Such attempts may lead to poisoning of the sensor and loss of calibration of the detector.

1.1.1 Disruption in the delivery of the target gas into the sensing element

Using Gas Detector should be aware that each detector will detect only those substances which will reach its measuring electrodes while each outside obstacle on free diffusion path of this substance to the sensor will cause functional properties reduction of the detector.

These obstacles can appear as well in the detector itself as in encircling atmosphere. This phenomenon can occur due to the following factors:

- humidity accumulation on the detector inlet,
- detected substance absorption by deposited humidity (this especially concerns substances reacting with water or being water soluble),



- rime depositing on the detector,
- for the substances depositing on the detector, such as solvents condensate, dust, paints, fat, etc.

The results can be as follows:

- sensitivity reduction,
- reaction time increase,
- total locking the sensor.

There should also be remembered that the sensor installed inside the measuring head is protected using the sinter of metal powders or PTFE membrane. As well sintered metal as the membrane are easy replacing elements and their role, among others, is to catch solid pollutions. Otherwise that would be easy to damage the sensor in irreversible way – due to locking physically inlet capillary tube. So, pollution accumulation on these elements is from the one side the phenomenon decreasing instrument performance parameters, but from the other side this is foreseeable and controlled phenomenon. The User should be aware of these phenomena and pay respect to them in his/her current operations by systematic control of the detector condition.

1.1.2 Masking substances presence

Can create the situation in which the detector will not detect the working substance due to other substance impact which influence to the sensor is opposite. Typical example is negative impact of Cl_2 on the NO_2 sensor.

Is no general solution to be applied, each case should be considered individually and consulted with the Manufacturer and system designer.

1.1.3 Presence of poisoning substances

- In the case of catalytic sensors (see appendix [5]).
- In the case of electrochemical sensors this is rather rare case but can be met. Each such case (gases combination, installation) should be considered individually and consulted with the Manufacturer (see appendix [6]).

1.1.4 Impact of gas high concentrations

This concerns sensors of any type:

- Catalytic sensors
 - In concentration higher than 100% LEL the sensor can be damaged due to too intensive process
 of gas oxidation on active element.
 - From some concentration values in most cases above UEL thermoconductivity phenomena become prevailing in the sensor, being symptomatic with reversing the detector characteristics. So at very high concentrations detector indications will be non univocal (identical as for concentrations below 100% LEL). This phenomenon is really dangerous especially in closed rooms (no ventilation), for such gaseous substances as methane.

Liquid vapours concentration is very often limited by the fact of ambient air saturation with these vapours in a given environmental conditions (ambient temperature and atmospherical pressure).

The user must be aware of the aforementioned phenomena and, considering the substances he or she works with, he or she should treat the indications of the device with appropriate criticism.



Electrochemical sensors:

• measurement ranges of these sensors are very often limited to some ppm. Appearing concentrations of % order creates very serious overloading (1% = 10 000 ppm) and leads to sensor damage or to very serious sensitivity and life cycle reduction.

The detector is equipped with high gas concentration detecting and signaling mechanisms. But the User should remember that this does not solve the problem of gas impact to the sensor – mechanical cut-off of noxious gas inflow to the detector is impossible.

1.1.5 Impact of temperature and humidity

The Gas Detectors should be operated under environmental conditions meeting data determined in this document. Limit values exceeding can result – especially in the case of electrochemical sensors, in:

- in the case of humidity below 10% sensor drying i.e. reduction of its life cycle,
- ✓ in the case of humidity above 90%, maintaining during longer period sensor "swelling" and unsealing caused by humidity absorption from ambient air.

Situations, described above, are dangerous only when are of permanent or long lasting character. Instantaneous exceeding of those values has no important meaning for the sensor life cycle duration.

1.1.6 Detector flooding

Flooding the measuring head with water can lead to the detector damage. Especially dangerous are flooding with chemical substances – effect is unforeseeable and even correct operation just after flooding does not guarantee such correct operation in future.

In the case of the detector flooding there is necessary to inform immediately the Manufacturer about this situation. The User should expect that sensor replacement can be necessary.

1.1.7 Repairs and modifications in the installation



Any unauthorized modifications in the detector or its installation are inadmissible.

1.1.8 Electromagnetic compatibility

The detector has appropriate electromagnetic compatibility degree suitable for industrial conditions — as the instrument. That is the reason that the person developing detail engineering and installation should take care to maintain accordance with concerning requirements — also e. g. of those concerning lightning protection. It should be remembered that the installation Contractor is responsible for correct installation functioning in the scope of electromagnetic compatibility.

Conformity to directive does not exclude problems related to this compatibility during the system installation phase (due to e.g. non-typical equipment operating, etc.). In such situation this problem has to be solved individually on the base of mutual agreement between Manufacturer(s), installation Contractor and Customer.



1.2 Purpose

Gas Detector ProGas / Sigma ProGas is stationary instruments intended for detection and monitoring of toxic, flammable and oxygen gases.



Gas Detector ProGas / Sigma ProGas cannot be installed within explosion hazardous zones.

The instrument measures a given component concentrations and subsequently converts it – depending on model (described hereafter) – to current or digital signal. In addition to measurement execution, the detector analyses value of the concentration measured and is able to inform about the following threshold values exceeding:

- warning 1,
- warning 2,
- alarm,
- gas overloading (hazard of the instrument damaging).

Additionally, the detector is self-diagnostic device – and in the case of operational abnormality finding it informs users about this fact.

1.3 Description of the construction

1.3.1 Basic functionality

Gas Detector ProGas / Sigma ProGas characterized:

microprocessor design

It allows for offering high, competitive operating parameters in relation to classic solutions, based on analogue technology. Microprocessor design:

- · measurement signal reading and linearisation,
- ambient temperature impact compensation,
- switching over the detector to determined operational modes (e.g. calibration mode, alert mode),
- detector status diagnosis.
- "in situ" signal processing

immediate, performed inside the detector, signal processing to digital form, increasing this way the instrument reliability and its interferences resistance

- no mechanical adjustment elements
 - all presets are saved in non-volatile memory inside the detector, what allows to resign of any potentiometers, change-over switches and other similar mechanical elements. Applied solution increases instrument reliability
- non-invasive testing and control
 - model of the detector equipped with RS-485 interface can be calibrated with no need to open the casing. In most cases the detector dismantling from its operational location is unnecessary.
- flexible configuration of output signal

the detector output signal form can be as follows:



- current signal 4 20mA,
- digital signal RS-485,
- · contact outputs (relays).

In expanded models of this detectors, simultaneous use of two selected signal forms is allowed

- non-invasive configuration
 - values of alert thresholds can be changed with no need of system shutdown (RS-485 model)
- ✓ self-diagnostic

The following, among others, can be checked:

- correctness of the detector power supply,
- overloading status,
- · elapsing of time periods between necessary testing,
- processor memory damages.

1.3.2 Detected gases

Depending on which gas the detector is intended for, the Manufacturer selects appropriate type of sensor (to avoid misunderstanding there was decided that the "sensor" is name of the detecting element, converting gas concentration to electronic signal, while the whole instrument is called the "detector").

Information about sensors used in gas detectors can be found in the attachments:

- semiconductor sensors DET attachment [4],
- catalytic sensors attachment [5],
- electrochemical sensors attachment [6],
- photoionization sensors attachment [7],
- Hot Wire sensors attachment [8],
- / IR sensors attachment [9].

1.3.3 Output signal

Depending on the User needs the detector can operate with the output circuit configured as:

RS-485 output (applicable ProGas and Sigma ProGas)

This is the basic solution, recommended by the Manufacturer. It allows easy integration with: data transmission systems, visualization in instrumentation and control installations and industrial controllers.

Communication on RS-485 interface is carried on using Modbus ASCII / Sigma Bus protocol. Use of other protocols is also possible.

For detectors with RS-485 output the output signal has the digital form of electronic data. Generally status of the detector is described by the variables. Memory map of Gas Detector in Appendix [16].

standard current (analogue) signal 4 – 20mA (Gas Detector ProGas)

This allows easy integration with other automatics systems, e.g. with industrial controllers. Detectors with the output of this type are designated using "420" symbol,



- values below 4 mA are used to present various failure states of the detector (see Appendix [14]),
- the value of 4 mA reflects zero (0%) concentration of measured gas,
- the value of 20 mA reflect concentration equal to present range of the detector operation or higher concentrations (detector saturation status),
- current value for a determined concentration can be calculated using the following equation:

contact output (only ProGas)

The simplest solution – allows direct detectors utilization for executive equipment control. Detectors with the output of this type are designated using "CON" symbol.

Three contact signals are available which can be utilized as follows:

- PK1: warning 1,
- PK2: alarm,
- PK3: detector failure.

Parameters of relays are shown in Table 7.

2 Description of device operation

2.1 Measuring mode

The detector measures a given component concentration and subsequently converts it – depending on variant (described hereafter) – to current or digital signal. Additionally to measurement performance, the detector analyses value of concentration measured and is able to inform about exceeding the following threshold values:

- ✓ warning 1 gas concentration exceeded first threshold value,
- warning 2 gas concentration exceeded second threshold value,
- alarm gas concentration exceeded alarm level.

2.2 Gas overloading

Most of gas measuring sensors can operate only in determined range of gas concentrations and is sensitive to overloading. Overloading – especially extending ones – could lead to sensor damage – loss of sensibility. Such situation is very dangerous and it is the reason that modern detectors are provided with functions detecting overloading occurrence – to inform operators about the event and necessity to test and possibly to adjust detectors.

2.3 Overheating

Due to the fact that thermal overloads have negative impact on operation and service life, the gas detector stores such events.

2.4 Lock

For a specified type of sensor (catalytic, for flammable gases), the detectors have a lock function that protects the sensor against harmful impact of concentrations exceeding 100% of the Lower Explosive Limit. In case of toxic gases and electrochemical sensors, preventive disconnection of a sensor is not possible. However, the system registers and visualizes possible overloads in order to inform the service about this fact in order to allow it to e.g. commission inspection of the detectors after removal of the hazard. For additional information see Appendix [10].



2.5 Failures

The detector is self-diagnosing instrument and when any abnormality is detected the detector informs the User about it. During the detector operation two types of abnormalities can occur.

2.5.1 Critical failure

It makes the detector unable to continue operation and requires an immediate service action.

2.5.2 Non-critical failure

Further operation of device is possible but its metrological parameters might have been impacted (fg. time out for periodic calibration, small zero drift).

User should be informed about the failure states to plan the maintenance activities at the convenient time.

Failure codes in Appendix [15].

2.6 Services status

2.6.1 Calibration

In this state, the detector allows for change of its settings, it is also possible to check the detectors without triggering the alarm signalling (actually, the behaviour of the system depends on interpretation of data by the system's Control Unit).

The way of signaling the above conditions are described in Appendix [15] and [16].

2.6.2 Warming up

The detector prepares for operation and its parameters are stabilized. After approximately 60 - 180 seconds (depending on the type of a sensor, measurement range), normal operation of the device starts.

2.6.3 Inhibit mode (only Sigma ProGas)

It allows for a temporary deactivation – the detector in inhibit mode will be ignored by Gas Detection System.



Inhibit mode does not power off the detector.



In the Inhibit mode the detector continue its operation (so is prone to environmental factors like gas overload, temperature, renovations, etc.).



3 Description of the construction

The instrument consists of the following elements:

- enclosure (see Table 7),
- measurement head containing gas detecting element (sensor), made of stainless steel or plastic,
- one or two cable glands,
- microprocessor module electronic amplifier and measurement transmitter.

The detector should be mounted so, that its detectting element is directed downwards (see Table 7).

The Gas Detector can be optionally mounted by Mounting Adapter, allowing mounting detector in some distance from the wall. This way is obtained possibility to screw the splash-proof shield onto detector head and to avoid humidity accumulation on the detector in the case when water would flow down the wall.

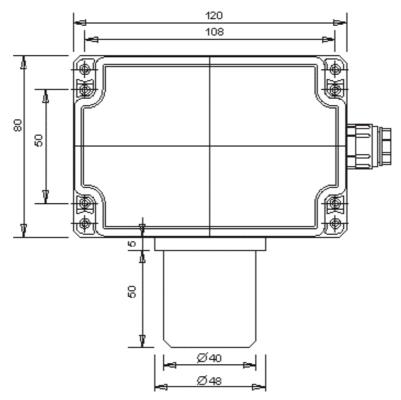
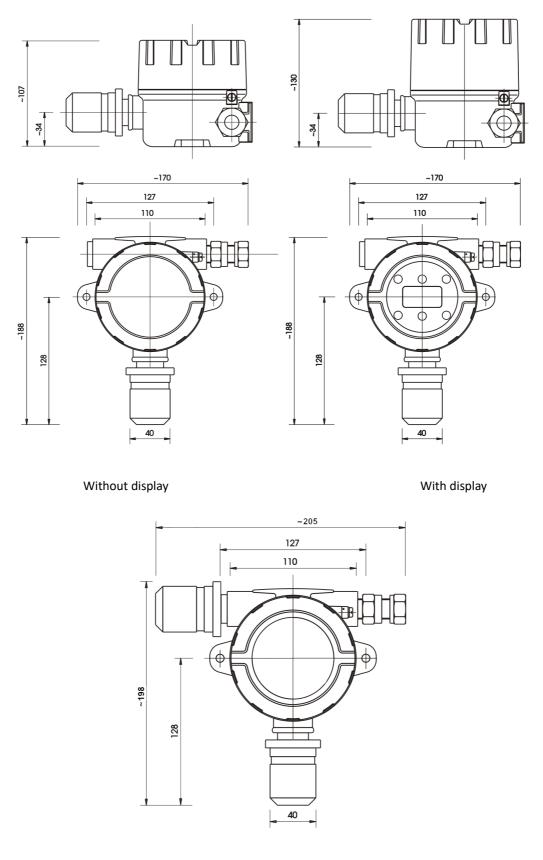


Figure 1: Gas Detector type PW-017 (option E = ABS, PC)





With acoustic signalling

Figure 2: Gas Detector type PW-017 (option E = ALB, ALZ, C, SS)



4 Input-output interfaces

4.1 Output RS-485 – only ProGas and Sigma Progas

4.1.1 Connection diagram RS-485

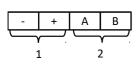


Figure 3: Connection diagram (RS-485)

No.	Name	Terminal	Description	
1	Power supply		Power supply port. Parameters – see section 8	
		-	Negative supply pole	
		+	Positive supply pole	
2	SBUS/RS-485		System communication port. Used for data exchange between devices in Sigma Gas system	
		А	Signal line A	
		В	Signal line B	

Table 2: Connection diagram description (RS-485)

4.1.2 Example of the connection diagram with RS-485 output

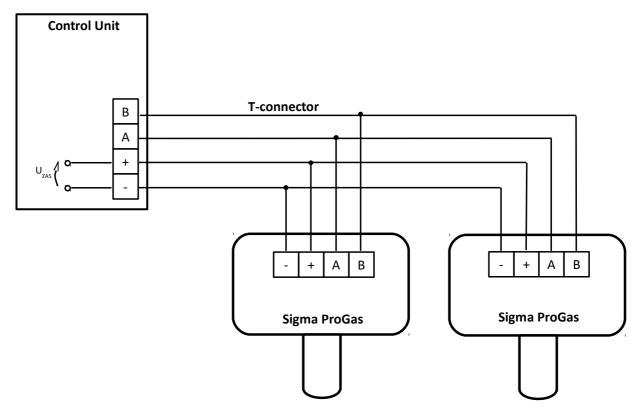


Figure 4: Example of the connection diagram with RS-485 output



4.2 4 – 20 mA (420) output – only ProGas

4.2.1 Connection diagram 420



Figure 5: Connection diagram (420)

No.	Name	Terminal	Description
1	Power supply / 420		Power supply port. Parameters – see section 8
		-	Negative supply pole
		+	Positive supply pole
		S	Active current output

Table 3: Connection diagram description (420)

4.2.2 Example of the connection diagram with 420 output

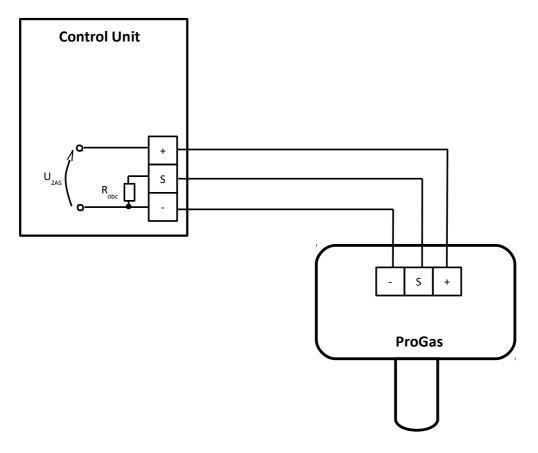


Figure 6: Example of the connection diagram with 420 output

Value of R_{obc} shown in Table 7.



4.3 RS-485 + 420 output – only ProGas

4.3.1 Connection diagram RS-485 + 420

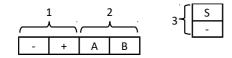


Figure 7: Connection diagram (RS-485 + 420)

No.	Name	Terminal	Description	
1	Power supply		Power supply port. Parameters – see section 8	
		-	Negative supply pole (internally circuited with a negative pole of the port 420)	
		+	Positive supply pole.	
2	SBUS/RS-485		System communication port. Used for data exchange between devices in Sigma Gas system	
		А	Signal line A	
		В	Signal line B	
3	420		Output port of 420 signal	
		S	Active current output	
		-	Negative supply pole (internally circuited with a negative pole of the port 420)	

Table 4: Connection diagram description (RS-485 + 420)

4.3.2 Example of the connection diagram with RS-485 + 420 output

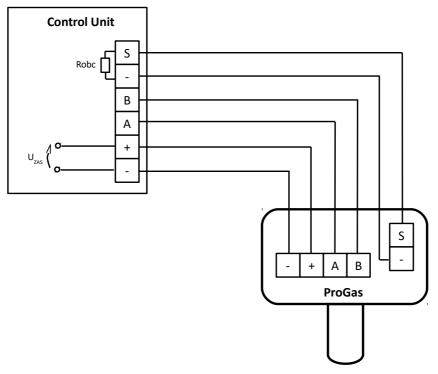


Figure 8: Example of the connection diagram with RS-485 + 420 output

Value of R_{obc} shown in Table 7.



4.4 420 + relay output – only ProGas

4.4.1 Connection diagram 420 + PK

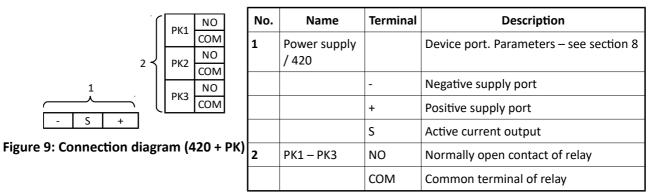


Table 5: Connection diagram description (420 + PK)

4.4.2 Example of the connection diagram with 420 + PK output

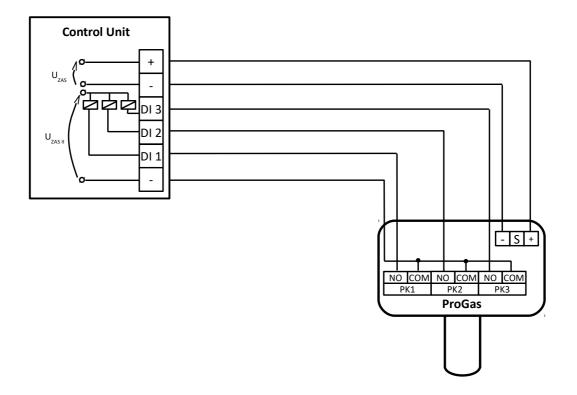


Figure 10: Example of the connection diagram with 420 + PK output



5 User's interface

Detailed description of the user interface are given in Appendix [15].

6 Cooperating devices

6.1 Gas Detector Sigma ProGas

Gas Detector Sigma ProGas it is designed to work with all devices with a prefix Sigma.

6.2 Gas Detector ProGas

Gas Detector ProGas can work with devices Atest-Gaz production as well as devices from other manufacturers.

6.3 Cooperation with devices other producers

When integrating Atest-Gaz detectors with devices of other producers, take into account technical specifications of particular devices.

In case of integration of the gas detection system using other devices e.g.: PLC or control units of other producers, the integration must be carried out in a way which prevents masking of any of information available in the detector or prevents change of meaning of any information. Lack of correct signal should be indicated as a special state (e.g. failure). Additionally, the system must support all phases of the detectors' service life.

7 Life cycle

7.1 Transport

The device should be transported in the same way as new devices of this type. If the original box or another protection (e.g. corks) is not available, it is necessary to secure the device against shocks, vibrations and moisture on one's own, using other equivalent methods.

7.2 Installation

Gas Detectors installation should be carried out in accordance with general rules of instrumentation installation. There should be remembered that ProGas / Sigma ProGas detectors are not intended for operation within explosion hazardous zones.

Conductors should be installed in such a way to protect them against damages. Routing them in cable trays is recommended.

If stranded cables are used to connect the unit, use bushing terminals to the ends of these cables.

7.2.1 Gas Detectors location

Gas Detectors location should be determined by the system engineer and should consider such factors as:

- density of detected medium in relation to the air density.
 - Generally, Gas Detectors of light gases are mounted in the distance of approx. 30 cm below the ceiling while heavy gases Detectors approx, 30 cm above the floor.
- spots of probable gas accumulation due to potential lack of ventilation or also due to specific design of concerning structure (e.g. a part of ceiling fenced by structural elements from other parts),



gas temperature impact.

Substances heavier than air after heating become lighter and move up – but after cooling can flow down to floor.

- pressure and expected type of outflow (leakage/ejection),
- gas volatility.

In the case of substance of low volatility the detector should be placed possibly near to expected place of leakage

impact of environmental conditions

The detectors should not be exposed to direct influence of water or other chemical substances – e.g. cleaning agents during cleaning. Special care should be paid to allow no flooding/dirtying the sintered steel, because this will cause loss of detector measuring capabilities.

The detector should be also protected against direct influence of dust, sunbeam, rain and wind. When detectors are to be installed directly outdoors, use of appropriate splash-proof shields or weather enclosures is necessary. The detector should not be exposed directly to environmental conditions impact. Negligence to follow these rules will lead to the sintered steel or sensor damage.

ventilation direction

The detectors should be mounted in spots located on ventilation routes – from the leakage to exhaust. In the case when this route could be changeable – four detectors should be foreseen to encircle source of potential emission. In the case of outdoor installation – taking into account expected wind direction is necessary.

probable place of people presence in relation to emission source.

Detectors should "separate" personnel from this source,

mechanical impact

The detector is made using aluminium, high resistance casing, resistant to very strong mechanical shocks. However, the detector should be protected against such destructive exposures. In the case of damages occurrence, especially to surfaces of flame-proof joints, threads or sintered steel – the detector should be switched off, connecting cables protected and the service contacted.

access

Detector location should allow detector inspections and adjustment carrying carrying on as well as its replacement or disconnection.

7.2.2 Environment

During detectors installation engineering the following factors should be considered:

corrosivity

The device can be installed and used in environments creating no corrosion hazard for applied materials. Although the detector design applies appropriately resistant materials and corrosion protection means the User or Engineer should develop the "Environmental conditions assessment" taking into account such factors as:

- presence of such gases as SO₂, HCl, H₂S, NH₃ and other corrosive substances, especially in high humid atmospheres,,
- possible changes of ambient temperature and their adequacy to values declared in this document.



- in the case of chemically active substances such as HCl, Cl₂ special attention should be paid to hazard of a given substance absorption on the detector surface, especially in high humid environments,
- probability of dust, fat and other adhesive substances deposition, especially on gas inlet element leading to the measurement chamber,
- probability that hot vapours of substances being liquid in ambient temperature could appear
 what creates danger of this substances condensation inside the detector resulting in possible detector locking,
- ambient temperature
 - It should meet values declared by the Manufacturer. Especially during process installation start-up and during process installation failure situations the User should pay attention to check if instantaneous overruns of temperature range have occurred and if their occurrence is confirmed contact the Manufacturer (typical situations e.g. welding the structure where instrument is mounted),
- danger of detector flooding with water or other liquid,

when the detector is installed outdoors:

- the detector should not be exposed to direct impact of environment conditions, use of appropriate splash-proof shields or weather enclosures is necessary,
- the detector should be protected against humidity condensation on its surfaces because this
 can result in inlet sintered steel locking. Protection is possible by e.g. heating the detector by
 some Celsius degrees,
- oxygen concentration in detector surroundings it is especially important for pellistor detectors, oxygen concentrations below 20% substantively decrease the sensor sensitivity,
- features of different sensors (measurement techniques) are described in the appendix: [4], [5], [6], [7], [8] and [9],
- vibrations

Excessive vibrations can cause bolts and cable entries unscrewing, therefore in cases of such situations there is necessary to place in the engineering documentation an appropriate requirement concerning more frequent inspections (e.g. more frequent examination inspections in the form of close visual inspection).

7.2.3 Electric installation

Electric installation of the detectors can be made only by appropriately qualified persons or persons acting under agreement with and supervision of the Manufacturer.

The below order should be followed during electric connections installing:

- ensure that conductors to be connected are disconnected from any electric circuits,
- ensure that there is no fire hazard during installation works,
- unlock cover of the gas detector,
- remove the detector cover,
- loosen the cable glands,
- after conductors preparation (removing insulation on ends) insert the cable through the cable glands,





Pay attention if cable outside diameter matches cable glands type used.

make all connections according to electric diagram,



Attention should be paid that uninsulated ends of cables cannot create short circuits with non-insulated elements of the detector. To the device, enter only the necessary amount of cable (without reserve).

- / lay cable appropriately i.e. in such a way that no mechanical stress impacts this cable,
- tighten the cable glands,
- put the gas detector cover on place ensuring that cover gasket is correctly laid,
- tighten bolts protecting the cover.

On the Control Unit side the screens should be connected to earthing.

The Gas Detectors cables should be carried out as far as possible from the power cables, preferably in separate trays.

Without the use of additional intermediate modules, the total number of detectors connected to a single bus may not exceed 32 units. Use of intermediate modules allows for increasing this number to 250 (provided that the control unit can "support" more than 32 detectors).

7.2.4 Line design

Auxiliary materials are in Appendix:

- Appendix [11] RS-485 output,
- ✓ Appendix [12] 420 output,
- Appendix [13] output relays.



Don't duplicate data transmission cables because it can cause hepatic impedance. Table with the recommended types of cables can be found in the Appendix. Other recommendations are in line with the general rules that govern the design of the line.

7.3 Start – up

Factory new sensors are calibrated and verified. Most often, a correct installation ensures that the detector does not require additional processes. If there is a need to check the system, the best way is to supply, using Calibration Mask, calibration gas and check whether the detector/system behaved as expected.



It is forbidden to test the detector using a gas of unknown contents and/or high concentration. This may cause permanent damage of the sensor.

The start – up process can be commenced only after the security of all persons who check the system is ensured.



7.3.1 Gas Detection System Start – up

Take special care when commissioning the Gas Detection System. However, if it is impossible, it is necessary to observe all principles associated with safe manipulation of electric devices.

In the case of wide spread installation there is recommended to connect detectors successively and their stepwise start-up. This approach will facilitate finding and removing possible errors made during installing process.

Detector behavior after power supply and it operation are described below.

After all electric connections are completed and accepted for operation the installation is ready for operation.

7.4 Device / system configuration

Communication port SBUS is equipped with line terminator. To configurate his operation – open the sensor housing, and put the jumper in the connector termination.

Jumper settings	Operating	Scheme
□ □ JP1	Terminator port off (default setting)	Α ———
		В ———
JP1	Terminator port on	A

Table 6: Configuration of the line terminator

7.5 Diagnostics

7.5.1 Checking

Detectors checking is performed without detectors dismantling.

In some cases there could be, after all, necessary to dismantle detectors for checking – e.g. HCl detectors.

Checking is performed by feeding test gas of concentration higher by 20% than the alarm threshold value - or of concentration equal to 50 - 100% of the measurement range and detector behaviour observation.

Gas is fed from appropriate cylinder/bag using calibration cap screwed onto the measuring head. In some cases there is necessary to use appropriate gas measurement syringes simulating gas diffusive propagation (e.g. in the case of phosgene). The detector capable for further operating should generate the alarm signal.

Detector characteristics drift could be of two types:

- towards "negative concentrations" (sensitivity losing)
 - Test gas feeding allows to reveal sensitivity loss greater than 20% of preset value. According to principles, presented in further part of this document, no alarm generation after test gas feeding means necessity of recalibration and readjustment.
- towards "positive concentrations"

This drift is univocal with lowering thresholds of detector reactions and is being found by current observation of detector indications.



Even in the case when no observation is conducted, if the drift will exceed a determined value the detector will signal first alarm threshold overrun. Because the detector during operation can indicate also presence of background (pollutions) there is recommended, in justified cases, to check detector "zero" using pure air in cases where detector indications will reach startling values (e.g. 50% PEL) — to check if the indication reflects existing contamination or it is caused by characteristics drift.

Independent on occurring alarms, observing actual detectors indications is recommended – in systems allowing it.

Calibration function installed in detectors allows indications observing with no system alarms generation making possible that the checking has not to be associated with whole surroundings alarming. However, there is recommended to check whole alarm line – from detector to executive equipment during each inspection, for some detectors as minimum (during the acceptance inspection – for all detectors).

Detectors are switched over to calibration mode using appropriate function of the software tools.

Detectors should be switched over to calibration mode individually or per groups. Performing this process by a team (minimum two persons) is more suitable assuring communication between dispatcher and operator using e.g. radio-telephone. In the case of extensive installations there is recommended to carry the checking on cycle wise – assuming that only a determined group of detectors is subjected to checking, each day; e.g. detectors located in a given facility can be grouped in chessboard, what in fact increases checking efficiency.

7.6 Periodical operations

7.6.1 Gas detector's ranking

In the case of wide spread installations, the User should develop appropriate "ranking of importance" for all detectors used. A given detector positioning in this ranking could be helpful in determination periods between checking and calibrations.

Activities related to detector operating can be split to:

- checking feeding with gas of control concentration to check correctness of detector reactions,
- resetting during operation, the detector may indicate minor gas concentration despite the fact that in reality there is no gas in the building. In such a situation, the reset function should be used (available in devices cooperating with the detector, e.g. in the control unit), the use of this function will result in change of the detector's indication to zero. The reset function is available only for a narrow range of detector's indications (there is not hazard of resetting high concentrations),
- calibration feeding with gas of calibration concentration and pure air to correct processing characteristics.
- inspection general assessment of detector technical condition,
- maintenance activities to maintain or recover technical conditions allowing further operating.

All above listed activities can only be carried on by trained servicemen, according to current technology status, general rules of safety and specific conditions of installation which should be collected into the form of procedures valid in a given works. The Customer or persons appointed by him/her to be responsible for safety in this works determines personnel admitted to detectors servicing activities, defined above, and scope of tasks assigned to them (i.e. full servicing or split to particular tasks).

Persons performing service activities should be appropriately authorized:



- checking operational service, trained by the Manufacturer,
- calibration and adjustment the Manufacturer's service,
- ✓ inspection, maintenance the Manufacturer's service.

No works may be executed when gas hazard is expected.

If, although the gas hazard expected, disconnecting of detectors is necessary substitute measurement performing is required using e.g. appropriately located portable detectors.

Performing substitute measurements is recommended in any situation when the basic detection system functioning is restricted.

The checking/calibration/adjustment process should be well prepared and last possibly short.

7.6.2 Calibration

Calibration should be performed when:

- negative result of detector checking was obtained, or
- detector environmental overloading occurred,
- no less frequently than:
 - or catalytic sensors: 3...9 months, depending on location,
 - for electrochemical sensors: 6...12 months, depending on location.

Detectors calibration should be made in laboratory under fume hood (Manufacturer's recommendation). In the case when due to some important reasons detector dismantling is impossible, calibration "in situ" (i.e. without detector dismantling) is permitted. This decision belongs to the Customer (or person(s) appointed by the Customer as responsible for works safety) and the Customer takes the responsibility for it.

After adjustment process completion, repeating detectors checking is necessary to protect against potential errors during adjusting and programming.

Detector calibration is conducted in digital way. It requires to connect PC class computer (e.g. notebook) to:

- ✓ detector data bus for RS-485 versions,
- detector directly after opening the casing.

The following calibration methods are available:

laboratory method

Detectors dismantling and "lege artis" cables securing and subsequently calibration in laboratory under fume hood (Manufacturer's recommendation).

direct method

Connecting notebook directly to detector – calibration "in situ" requiring the casing opening, admissible only after undertaking appropriate safety means – e.g. during process shutdown, with gas hazard control using independent instrument and after appropriate agreeing with installation owner.



remote method

Connecting notebook to the system data bus. This method is recommended by the Manufacturer.

The main advantage of this method is that during calibration no mechanical operations on detectors are necessary (e.g. casing opening) – excepting screwing the calibration caps on and gas feeding. This method allows also parallel data analyses by the system Manufacturer provided that remote data transmission method is used – WWW network, phone modem, etc.

Calibration/adjustment procedure is as follows:

- switch over selected Gas Detectors to calibration mode control unit recognize calibration mode it allows avoiding unnecessary alarming neighbourhood due to detectors reaction to test gas.
- switch on recording mode in the program,
- next feed the gas sequence high concentration/air/high concentration to particular detectors. Detectors indications are automatically recorded in the service tool,
- data analyses entering correcting factors to detectors,
- switch off the calibration mode,
- repeat detectors checking.

During calibration the following data are being determined:

- characteristics drift degree,
- sintered steel dirtying degree (T90 reaction time measurement),
- sensor wearing degree,
- detector power supply state (if concerns).



Description presented above is simplified. Calibration can be carried out only by someone authorized by the producer after participating in a proper course .



The calibration should be performed with the help of a matching set which can be purchased from the manufacturer's Gas Detector.

7.6.3 Replacement of consumables

Details of the lifetime of consumables can be found in Table 9.

7.6.3.1 Replacement of the sensor

Sensors lose their metrological parameters during operation in the natural way. This phenomenon is compensated by periodical and systematic indications adjustment — until replacement of the sensor is necessary. There is assumed that this replacement should be made after sensitivity drops below 50% of the original sensitivity.



Installation and disassembly of the measurement head sensor



It is recommended that all manipulations in the measurement head were executed by the producer's service or appropriately trained persons. Replacement of a sensor must always be followed by calibration of a detector. All manipulations must be carried out when the detector's power supply is turned off.

In order to assembly and disassembly the head cover:

- loose the screw that locks the cover using an Allen wrench 1.5 mm,
- grab the conduit, do not allow it to turn (as it may damage the connectors inside the housing),
- unscrew the sensor's cover,
- remove the old sensor and install a new sensor in the head, paying attention to appropriate setting of connectors and correct position of the seal,
- apply a small amount of a petroleum jelly on the thread of the conduit,
- gently tighten the sensor's cover (until you feel a resistance),
- tighten the locking screw (if the screw does not screw in smoothly until it is fully concealed, it means that the components of the head are mounted incorrectly),
- supply calibration gas to make sure that the detector works properly.



Not all errors resulting from improper assembly are detected by the diagnostics system of the detector. Each disassembly and assembly of the measurement head must be verified by supplying gas and checking the detector's reaction to gas.

If you need to unscrew the conduit from the head, the tape inside the housing must be disconnected first.

7.6.4 Periodical inspections

The periodical inspections includes the following issues:

- visual inspection i.e. assessment of general technical condition,
- detectors checking,
- alarm lines checking for selected detectors.

As the periodical inspection result the report should be issued, presenting guidelines concerning:

- necessity to perform installation maintenance,
- necessity to perform detectors calibration and adjustments.

7.6.5 Detectors checking before examination inspection

In specific cases during the period before first examination inspection, detectors checking performing can be necessary – e.g. biweekly to determine detectors behaviour. Two weeks period can be too short to assess behaviour, e.g. environment corrosivity, so these checking should not be identified with the examination inspection.

7.6.6 First examination inspection

The first examination inspection is to assess aggressiveness of environment where inspected installation is located.



Basing on this inspection results the cycle of "Periodical inspections" is determined. The proceedings during the inspection as in point 7.6.4.

7.6.7 Inspections resulting from operating conditions

In the case of high importance installations there is assumed that conducting detectors checking after their each activation as well as after each process breakdown in the works (impacting possibly the detectors, but causing no detectors reaction — e.g. flow out of hot steam) is necessary. Criteria are being determined individually, by agreeing them with process engineers of concerning works, defined in the form of "rules of safe system operating" for a given works, respecting these works specific and developed by experts responsible for these works safety or for a given process line safety.

Persons directly responsible for safe functioning of this system should be trained on safety rules in force within these works and obliged to undertake appropriate actions after failure situation occurrence.

7.6.8 Maintenance

During operation of the Gas Detection System the User should be aware of the fact that detectors — and especially all sensors, are elements susceptible to ageing and environment impacts. Therefore their maintenance process must be executed in systematic way. Generally it concerns two aspects:

- changing detectors characteristics
- keeping technical condition guaranteeing correct operation of the detector.

Characteristics changing can concern three issues:

- "zero" moving in direction of "positive" or "negative" concentrations,
- sensitivity loss;
- reaction time increase resulting from e.g. dirtying sintered steel element through which gas migrates inside the detector.

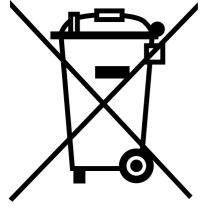


In case the device needs to be switched off (conservation or repair) please be aware the control unit will indicate a malfunction on the given channel.



All disconnections should be made when the supply voltage of the detectors is switched off.

7.7 Utilization



This symbol on a product or on its packaging indicates that the product must not be disposed of with other household waste. Instead, it is the user's responsibility to ensure disposal of waste equipment by handing it over to a designated collection point for the recycling of waste electrical and electronic equipment. The proper recycling of your waste equipment at the time of disposal will help to conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment. Information about relevant designated collection points can be obtained from the Local Authority, waste disposal companies and in the place of purchase. The equipment can also be returned to the manufacturer.



8 Technical specification

Power supply V cc Power consumption	12 – 30 V 0,48 – 3,6 W		
Environment ¹	In-operation Storage		
Ambient temperaturesHumidityPressure	$-20 - 40^{\circ}$ C (option T = 0) $-40 - 85^{\circ}$ C (option T = T) 10 - 90% long term 0 - 99% short term $1013 \pm 10\%$ hPa	0 – 40°C 30 – 90% long term	
Detected substance	Compatible with the Order or Calibra	ation Certificate	
Measuring range	As above		
IP	Safe conditions of the device work and uninterrupted access of gas to the sensor	Safe conditions of the device work and potential interrupted access of gas to the sensor	
	IP 63 IP 65 – using a Water-Splash Shield OB2 (PW-071)	IP 65	
Analogue output parameters ² 4 – 20 mA (only ProGas) • R _{OBC_MAX}	(option O = A / O = D, X = AL) 200 Ω		
Digital output parameters (only ProGas) • Relay	(option X = PK) 3 x NO 3 x NO / negated, 24 V DC, 0,2 A Not protected		
Digital communication parameters	RS-485Modbus ASCII 19200 7E1 (PW-01	7-PG), SigmaBus (PW-017-SP)	
Integrated signalling equipment (visual)	LCD alphanumerical display 2x8 with LED controls (option D = LCD, option not available for E = ABS, PC) FLED multi-colour display (D = FLED, D = FLED.A)		
Integrated signalling equipment (optical)	70 dB at a distance of 1 m (option D	= FLED.A)	
Protection class	III		
Dimensions	See Figure 1 and 2.		
Cable glands Cable diameter range External thread	6 – 12 mm (E = ABS, PC) 7 – 13 mm (E = ALB, ALZ) 8 – 13 mm (E = SS, C) M20		
Acceptable cables	0,5 – 2,5 mm ² (cable lugs 2 x 1 mm ² or 2 x 0.75 mm	² should be used for double wires)	

¹ Any of the below started parameters can be lowered by the parameters of the sensor.

f a higher value of R_{OBC} is needed please contact us.



Enclosure material	 ABS, PC Aluminium spray epoxy / SS316L (option E = Alx) Aluminium creodur epoxy / SS316L (option E = C) SS316L (option E = SS) 	
Weight	3.8 kg	
Mandatory periodic inspection	Every 12 months (Calibration Certificate validity) – time may be shortened due to difficult working conditions	
Lifetime of consumables	See table 9	
Mounting	 4 holes for the pin with diameter 4,5 mm or M4 (option E = ABS, PC) 2 holes for the pin with diameter 4 mm (option E = ALB, ALZ, C, SS) 	

Table 7: Technical specification

In the table below shows the gas detector current consumption depending on the device configuration.

Product code				Current consumption [mA]		
Floudet code					12 V	24 V
			0	_	20	20
		TS	LCD		45	35
			FLED	HL	125	75
		EL	0	HR	100	70
		ELm VOC	LCD		115	80
		DET	FLED		205	125
	PG SP IR PID	IR	0	HL HR	80	55
PW-017				нн	155	95
1 00 017			LCD	HL HR	95	65
				нн	170	105
			FLED	HL HR	185	110
				нн	260	150
		PID	0	НН	120	75
			LCD		145	90
			FLED		225	130

Table 8: Current consumption



9 List of consumables

No.	Consumables	Life time	Manufacturer	Product code
{1}	Sensor with gasket	Dependent on sensor type	-	-
{2}	Sintered cover	Dependent on sensor type	Atest Gaz	-
{3}	Cover without sinter	Dependent on sensor type	Atest Gaz	-

Table 9: List of consumables

10 List of accessories

Product code	Description
PW-063-A	Ventilation Adapter AW1
PW-071-A	Water-Splash Shield OB2
PW-064-WM1	Mounting Adapter WM1
PW-064-WM2	Mounting Adapter WM2
PW-064-WM4 ³	Mounting Adapter WM4
PW-069-DP1	Weather Housing DP1
PW-069-DP1WIN	Weather Housing DP1WIN

Table 10: List of accessories

11 Product marking

Туре	Description	Product code	
Gas Detector	ProGas	PW-017-PG-X	
Gas Detector	Sigma ProGas	PW-017-SP-X	

Table 11: Method of product's marking

More information regarding the configuration of the devices in order to determine the code of the product can be found in Appendix [2] (PW-017-PG) and [3] (PW-017-SP).

³ Mounting adapter can not be used for option D = FLED.A.



12 Appendices [1] DEZG014-ENG – EU Declaration of Conformity – ProGas, Sigma ProGas [2] PU-Z-071-ENG – ProGas hardware configuration marking PU-Z-072-ENG – Sigma ProGas hardware configuration marking [3] [4] PU-Z-030-ENG - Parameters of gas detectors with semiconductor sensors DET [5] PU-Z-054-ENG – Parameters of gas detectors with catalytic sensors [6] PU-Z-032-ENG – Parameters of gas detectors with electrochemical sensor [7] PU-Z-034-ENG – Parameters of gas detectors with photoionization sensors PID PU-Z-033-ENG – Parameters of gas detectors with Hot-wire sensors [8] [9] PU-Z-064-ENG – Parameters of gas detectors with IR sensor [10] PU-Z-093-ENG – Instructions for removing the lock of a detector with a catalytic sensor [11] PU-Z-003-ENG – Guidelines to the cabling of the system with an RS-485 interface PU-Z-074-ENG - Example of connection cables for gas detector PW-017 and PW-044 with [12] 4 - 20 mA output[13] PU-Z-076-ENG - Example of connection cables for gas detector PW-017 and PW-044 with relay output [14] PU-Z-036-ENG – Output current value of the sensor in fault state [15] PU-Z-073-ENG - The user's interface and failure codes of Gas Detectors of PW-017, PW-044 and PW-093 type [16] PU-Z-056-ENG – Register map of SmArtGas 3 and ProGas Gas Detector [17] PU-Z-039-ENG - Classification of chemicals used at Atest Gaz



EU Declaration of Conformity

Atest-Gaz A. M. Pachole sp. j. declares with full responsibility, that the product:

(Product description)	(Trade name)	(Type identifier or Product code)
Gas Detector	ProGas	PW-017
	Sigma ProGas	

complies with the following Directives and Standards:

- ✓ in relation to Directive 2014/30/EU on the harmonisation of the laws of the Member States relating to electromagnetic compatibility:
 - EN 50270:2006
- other:
 - EN 60529:1991

This declaration of conformity is issued under the sole responsibility of the manufacturer.

Purpose and scope of use: product is intended for use in gas detection systems for residential, commercial and industrial environment.

This EU Declaration of Conformity becomes not valid in case of product change or rebuild without manufacturer's permission.

Gliwice, 11.05.2017

(Name and Signature)
Managing Director
Aleksander Pachole

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ProGas hardware configuration marking

Davisa	Trade			Device code						Sensor	Cable gland	
Device	name	Туре	-	М	D	Н	E	т	О	х	s	W (Note 1)
							ABS PC					6 – 12 mm
Gas Detector	ProGas	roGas PW-017 PG		TS EL	0		ALB ALZ			AL AH PK		7 – 13 mm
			D17 PG VOC DET		HL HR HH	SS C	0 T	A D 3W		S-X-X.X / PWS-X-X.X	8 – 13 mm	
				IR PID	ALB	Z AL	AL AH		7 – 13 mm			
					FLED.A		SS C			PK		8 – 13 mm



Note 1: Cable gland 6-12 mm - material: polyamide. Cable gland 7-13 mm - material: brass nickel plated. Cable gland 8-13 mm - material: stainless steel. Cable gland mounted on the right.

	M – converter module	Limited use
TS	electrochemical	
EL	catalytic	
ELm	catalytic	• up to 40% LEL
voc	hot-wire	
DET	semiconductor	
IR	infra-red	
PID	photoionization	

	D – display	Limited use
0	without	
LCD	with window – LCD display and LED controls	 -20 – 50°C (Note 2) no possibility to realization for E = ABS, E = PC
FLED	with window – bright, multi-colour display	 -40 – 60°C no possibility to realization for E = ABS, E = PC
FLED.A	With window – bright, multi-colour display equipped with an acoustic signaller	 -40 - 60°C no possibility to realization for E = ABS, E = PC



Note 2: At -20°C the display contrast may be reduced (difficult to read).

	H – head		Limited use
HL	sensor cover with sinter, made of stainless steel	•	only hardly reactive gases ¹
HR	sensor cover without sinter, made of stainless steel and PTFE	•	reactive gases²
нн	sensor cover with sinter, made of stainless steel, warmed	•	possibility to realization for M = IR, M = PID

¹ E. g. CO, CH₄.

² E. g. Cl₂, HCN.



	E – enclosure	Limited use		
ABS	ABS	 Not resistant to UV action (use only inside buildings) -40 - 60°C no possibility to realization for D = LCD, D = FLED, D = FLED.A 		
PC	PC	 -40 – 80°C no possibility to realization for D = LCD, D = FLED, D = FLED.A 		
ALB	aluminium, spray epoxy – white			
ALZ	aluminium, spray epoxy – yellow			
С	aluminium, creodur coating – natural aluminium			
SS	stainless steel			

T – temperature range			Limited use		
0	standard		-20 – 40°C		
Т	increase temperature range for gas detector	•	-40 – 85°C (Note 3)		



Note 3: The maximum temperature range of the gas detector is limited by sensor, display or enclosure.

	O – output signal	Limited use
Α	4 – 20 mA	• Rob = 200 Ω
D	RS-485	
3W	Interface 3W	

	X – additional interface module	Limited use		
0	without			
AL	4 – 20 mA	 Rob = 200 Ω (only for D = 0) no possibility to realization for D = LCD and E = ABS or E = PC no possibility to realization for O = 3W 		
АН	4 – 20 mA	 Rob = 500 Ω (only for D = 0) no possibility to realization for D = LCD and E = ABS or E = PC no possibility to realization for O = 3W 		
PK	relay	 no possibility to realization for D = LCD and E = ABS or E = PC no possibility to realization for O = 3W 		

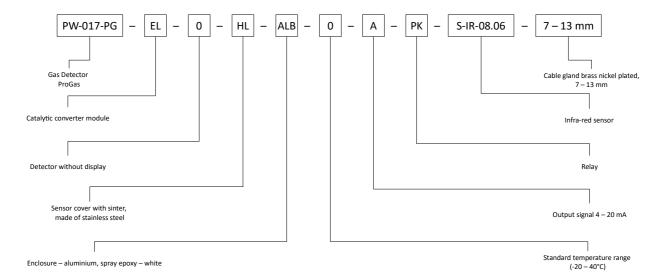
	S – type of sensor	Limited use
S-Y ³ -X.X ⁴	Electrochemical sensor	see appendix PU-Z-032-ENG
PWS-024-CAT-X.X	catalytic sensor module	see appendix PU-Z-054-ENG
PWS-024-HW-X.X	hot-wire sensor module	see appendix PU-Z-033-ENG
S-Sn-X.X	semiconductor sensor	see appendix PU-Z-030-ENG
S-IR-X.X	infra-red sensor	see appendix PU-Z-064-ENG
S-PID-X.X	photoionization sensor	see appendix PU-Z-034-ENG

For electrochemical sensor – symbol of the gas.

⁴ Two code numbers, specified for sensor.



Example





Sigma ProGas hardware configuration marking

Device	Trade name	Device code					Sensor	Cable gland					
	rrade name	Туре	-	М	D	н	E	Т	S	W (Note 1)			
Gas Detector							ABS PC		S-X-X.X / PWS-X-X.X	6 – 12 mm			
				TS EL	0		ALB ALZ			7 – 13 mm 8 – 13 mm			
	Sigma ProGas	PW-017	SP	VOC DET		HL HR HH	SS C	0 T					
			IR PID		IR PID	IR	IR	LCD		ALB ALZ			7 – 13 mm
					FLED.A		SS C			8 – 13 mm			



Note 1: Cable gland 6-12 mm - material: polyamide. Cable gland 7-13 mm - material: brass nickel plated. Cable gland 8-13 mm - material: stainless steel. Cable gland mounted on the right.

	M – converter module	Limited use
TS	electrochemical	
EL	catalytic	
ELm	catalytic	• up to 40% DGW
VOC	hot-wire	
DET	semiconductor	
IR	infra-red	
PID	photoionization	

	D – display	Limited use
0	without	
LCD	with window – LCD display and LED controls	 -20 – 50°C (Note 2) no possibility to realization for E = ABS, E = PC
FLED	with window – bright, multi-colour display	 -40 – 60°C no possibility to realization for E = ABS, E = PC
FLED.A	With window – bright, multi-colour display equipped with an acoustic signaller	 -40 – 60°C no possibility to realization for E = ABS, E = PC



Note 2: At -20°C the display contrast may be reduced (difficult to read).

H – head			Limited use
HL	sensor cover with sinter, made of stainless steel	•	only hardly reactive gases ¹
HR	sensor cover without sinter, made of stainless steel and PTFE	•	reactive gases ²
нн	sensor cover with sinter, made of stainless steel, warmed	•	possibility to realization for M = IR, M = PID

¹ E. g. CO, CH₄.

² E. g. Cl₂, HCN.



	E – enclosure	Limited use		
ABS	ABS	 not resistant to UV action (use only inside buildings) -40 - 60°C no possibility to realization for D = LCD, D = FLED, D = FLED.A 		
PC	PC	 -40 – 80°C no possibility to realization for D = LCD, D = FLED, D = FLED.A 		
ALB	aluminium, spray epoxy – white			
ALZ	aluminium, spray epoxy – yellow			
С	aluminium, creodur coating – natural aluminium			
SS	stainless steel			

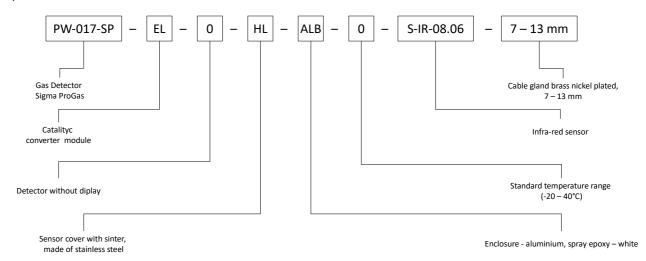
T – temperature range		Limited use		
0	standard	• -20 – 40°C		
Т	increase temperature range for gas detector	• -40 – 85°C (Note 3)		



Note 3: The maximum temperature range of the gas detector is limited by sensor, display or enclosure.

	S – type of sensor	Limited use
S-Y ³ -X.X ⁴	Electrochemical sensor	see appendix PU-Z-032-ENG
PWS-024-CAT-X.X	catalytic sensor module	see appendix PU-Z-054-ENG
PWS-024-HW-X.X	hot-wire sensor module	see appendix PU-Z-033-ENG
S-Sn-X.X	semiconductor sensor	see appendix PU-Z-030-ENG
S-IR-X.X	infra-red sensor	see appendix PU-Z-064-ENG
S-PID-X.X	photoionization sensor	see appendix PU-Z-034-ENG

Example



³ For electrochemical sensor – symbol of the gas.

⁴ Two code numbers, specified for sensor.

Appendix: PU-Z-o3o-ENG Ro2



Parameters of gas detectors with semiconductor sensors DET

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3.2 Influence of temperature	
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	4



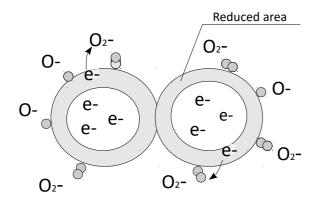
1 Detected substances

Semiconductor sensors are used for measuring and detecting presence of flammable and toxic gases.

2 Principle of operation

The principle of operation of the semiconductor sensor is to change the resistance of the semiconductor in the presence of the detected gas. The interaction of the gas phase with the surface of the semiconductor leads to the formation of chemical bonds between the gas particles and the absorbent material (the chemisorption process). In the air atmosphere, the surface of the semiconductor (of the n type) absorbs oxygen atoms which constitute the so-called "electron traps" (figure 1). When a detectable gas appears in the vicinity, the chemisorption of gas occurs in the presence of oxygen, electrons are released and an increase in electrical conductivity of the semiconductor occurs (figure 1).

The semiconductor material is usually made of tin oxide (IV). The measuring element is heated by means of a heater. In addition to SnO_2 other semiconductors are also applied, e. g.: TiO_2 , WO_3 , GaO_3 , GaO_3 .



oxygen adsorption on the semiconductor surface (without the presence of the detected gas)

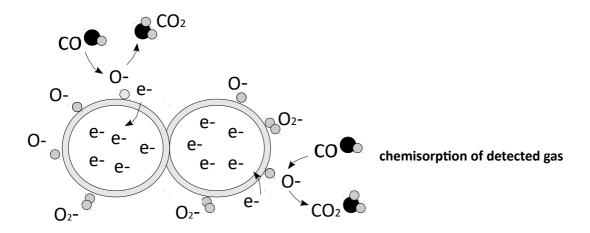


Figure 1: Principle of operation of semiconductor sensor

Appendix: PU-Z-030-ENG Ro2



3 Impact of environmental conditions



Never exceed the rated operating parameters of the detector. These parameters can be found in the detector calibration certificate.



The detector must be used in accordance with the provisions in the User's Manual.

3.1 Composition of the controlled atmosphere

It is assumed that the standard composition of the atmosphere is a mixture of gases with the proportions indicated in table 1.

Ingredient	C [% vol]	C [ppm]
Nitrogen	78.084	780 840
Oxygen	20.946	209 460
Argon	0.934	9 340
Carbon dioxide	0.0360	360
Neon	0.00181	18.18
Helium	0.00052	5.24
Methane	0.00017	1.70
Krypton	0.00011	1.14
Hydrogen	0.00005	0.50
Xenon	0.000008	0.087

Table 1: Typical composition of atmospheric air

3.1.1 Impact of the presence of a substance in a controlled atmosphere

- The semiconductor sensors are non selective (cross sensitivity).
- Presence of corrosive gases (e. g. NH_3 , H_2S , SO_2) causes a decrease in the sensor's sensitivity.
- Reactive gases (e. g. SO_2 , NO_x) can overstate or lower received signals.
- Prolonged high working gas concentrations have an influence on the sensor characteristics, regardless of whether the sensor is energized or not. In extreme cases it is possible to irreversibly damage the sensor.
- The prolonged presence of low working gas concentrations causes a slow saturation of the sensor.

3.1.2 Effect of oxygen concentration value

The concentration of oxygen affects the operation of the sensor. The semiconductor sensor should operate in an atmosphere of standard oxygen concentration. The minimum permissible oxygen concentration at which a semiconductor sensor can operate is 18%.



3.2 Influence of temperature

Temperature changes have a very significant influence on the sensor characteristics – these changes can lead to false alarms. Temperature impact models are very irregular, which makes good temperature compensation very difficult.

3.3 Influence of pressure

Within the environmental parameters of the sensor, the influence of pressure on the measurement is negligible.

3.4 Influence of moisture

Moisture changes clearly affect the sensor characteristics, while sudden changes can lead to false alarms. Humidity impact models are very irregular, which makes good humidity compensation very difficult.

3.5 Influence of vibrations, impacts

Vibrations and impacts may cause damage of the sensor.

4 Factors shortening the lifetime of the sensor

Semiconductor sensors can operate from 5 to even 10 years. However, there are a number of factors that can shorten their lifetime:

- / high concentrations of poisons, e. g. organometallic compounds, organophosphorus compounds, sulphur compounds, halogen compounds, olefins,
- silicone vapours absorb themselves on the surface of the sensor, gradually decreasing its sensitivity. Avoid exposure of the sensor to silicone adhesives, silicone latexes, raising agents, oils, greases,
- / high concentrations of corrosive gases (mainly NH₃, H₂S, SO₂, HCl),
- presence of concentrations well beyond the measuring range,
- very dirty atmosphere or with constantly high humidity,
- the strong non-linearity of the processing characteristics causes these sensors to work mainly as leakage detectors:

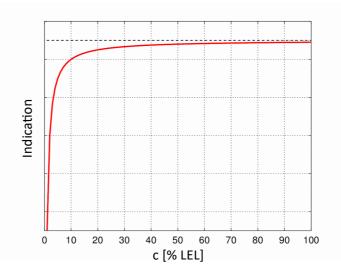


Figure 2: Characteristic of semiconductor sensor



Parameters of gas detectors with catalytic sensors

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1 Detected substances

Detectors equipped with catalytic sensors are used for measuring and detecting the presence of gases and flammable gases in the range of up to 100% LEL.

2 Principle of operation

The catalytic sensor (figure 1) consists of two components: an active and a passive one, heated to a high temperature. They are both constructed of a very thin coiled platinum wire, however, the active element (figure 2) is additionally coated with a catalyst (e. g. palladium, platinum). A combustion reaction occurs on the active element. Heat is generated as a result, which causes an increase in the temperature of this element and a resultant change in its resistance. Whereas combustion is not possible on the passive element, therefore, its properties do not change under the influence of a combustible substance. This allows the passive element to compensate for the impact of ambient temperature. The same resistance change of both elements occurs when the ambient temperature changes. The passive and active elements are integrated in the Wheatstone bridge circuit, which ensures conversion of the change of resistance to voltage.

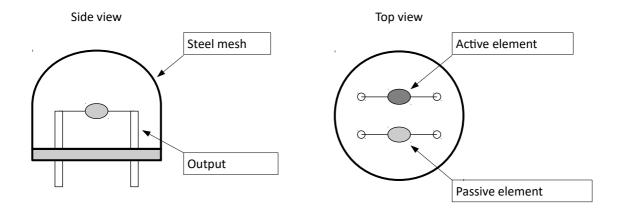


Figure 1: Sample view of catalytic sensor

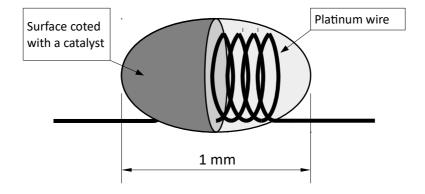


Figure 2: Active element construction



Impact of environmental conditions 3



Never exceed the rated operating parameters of the detector. These parameters can be found in the detector calibration certificate.



The detector must be used in accordance with the provisions in the User's Manual.

3.1 Composition of the controlled atmosphere

It is assumed that the standard composition of the atmosphere is a mixture of gases with the proportions indicated in table 1.

Ingredient	C [% vol]	C [ppm]
Nitrogen	78.084	780 840
Oxygen	20.946	209 460
Argon	0.934	9 340
Carbon dioxide	0.0360	360
Neon	0.00181	18.18
Helium	0.00052	5.24
Methane	0.00017	1.70
Krypton	0.00011	1.14
Hydrogen	0.00005	0.50
Xenon	0.000008	0.087

Table 1: Typical composition of atmospheric air

When gas concentrations in the atmosphere differ significantly from those indicated in the table 1, it is necessary to conduct the analysis of the impact of such a situation on the detector operation.



Catalytic sensor working properly at an oxygen concentration of about 21%.

3.1.1 Impact of the presence of a working gas or other reaction gas

Catalytic sensor isn't selective – it reacts (with different sensitivity) to most flammable substances appearing in its surroundings. Because of that it is necessary to consider their presence when the sensor is operating.

When using detectors with catalytic sensors, it is necessary to be aware that:



long-term presence of significant concentrations results in faster sensor wear. Basically, catalytic sensors are used to detect the incident presence of combustible gases. They should not work in atmospheres in which flammable gases at concentrations greater than about 20% LEL occur in a continuous or prolonged manner, as it may lead to a rapid reduction of their sensitivity and the appearance of a zero drift,



- concentrations over 100% LEL, even temporarily persistent ones, can lead to a physical wear of the sensor. For these reasons, detectors operating in places where such conditions may occur are / should be equipped with mechanisms to prevent the negative effects of high concentrations,
- a very high concentration of combustible gas (well above 100% LEL) leads to a decrease in oxygen concentration thereby lowering the sensor's indication. Volumetric concentrations close to 100% can result in a zero sensor response, as shown in the figure (example: a small room and a large amount of flammable gas released into the atmosphere). See section 3.1.2.

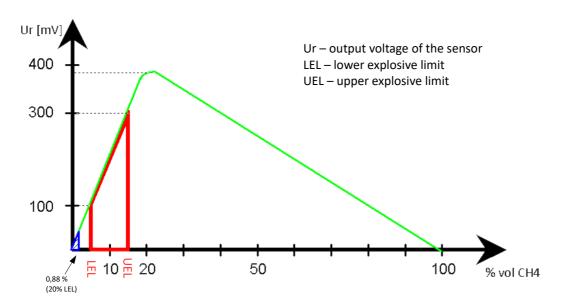


Figure 3: Sample characteristic of catalytic sensor

3.1.2 Effect of oxygen concentration value

Oxygen is required for a proper operation of the catalytic sensor. If the monitored atmosphere contains gas or gases that dilute or replace air (thereby reducing the oxygen concentration), for example, nitrogen or carbon dioxide, then the catalytic detector can give a low or even zero response.

A similar effect can occur when large amounts of reaction gas are released to the atmosphere(creating a concentration over the measurement range) – due to a too low amount of oxygen, the concentration indication of the detector will be lower than it actually is, and it may even be zero.

3.2 Influence of temperature

The temperature can have an influence on the sensor's characteristics. Within the scope of the detector's environmental parameters, its influence is compensated electronically.

3.3 Influence of pressure

Within the environmental parameters of the sensor, the influence of pressure on the measurement is negligible.

3.4 Influence of moisture

Within the environmental parameters of the sensor the influence of moisture on the measurement is negligible.



3.5 Influence of vibrations, impacts

Vibrations and impacts affect the detector's operation, as they may cause:

- damage to delicate parts of the sensor (e.g. detector element, compensation element),
- shift of the sensor's zero.

It should be ensured that the detector is not exposed to shock and vibration in excess of the amplitude of vibrations amounting to 0.15 mm of the frequencies of over 10 Hz. Under no circumstances should the peak acceleration exceed the value of 19.6 m/s^2 .

3.6 Influence of physicochemical phenomena

- In the case of chemical compounds with high flash point (approx. 50°C and above) it is necessary to remember that in typical environmental conditions (ambient temperature below 40°C), it is unlikely that they will be able to produce atmospheres close to 100% LEL. Particularly in the case of ambient temperatures below 0°C it may occur that achieving measurable concentrations by the catalytic sensor (of 10% LEL) is impossible. Another measurement method is required in this case.
- High concentrations of inserting gases (e. g. argon, helium) can change the thermal equilibrium of the sensor, resulting in the apparent reading of the presence of a combustible substance.

4 Factors shortening the lifetime of the sensor

4.1 Poison and inhibitors

For every reaction with the presence of a catalyst that cause permanent (poisons) or temporary deceleration (inhibitors) of this reaction, which results in reduced sensor sensitivity – in particular the lack of reaction to a combustible substance.

For catalytic sensors, on the active element side, we distinguish the following poisons:

- silicons (organosilicone compounds) e. g. PDMS (polydimethylsiloxane), HDMS (hexamethyldisiloxane), sealants, adhesives, raising agents, specific oils and lubricants, some medical supplies,
- organometallic compounds e. g. Grignard compounds, lead tetrachloride (leaded petrol, certain aviation fuels).
- ✓ organophosphorus compounds e. g. in herbicides, insecticides, phosphoric esters in fire-proof hydraulic fluid,

and inhibitors:

- sulfur compounds e. g. hydrogen sulfide, mercaptans, carbon disulphide, sulfur dioxide,
- / halogen compounds e. g. methyl chloride, some freons (among others R134a), vinyl chloride,

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olefins – e. g. styrene, propylene, acrylonitrile.

Acetylene is a poison for the passive element of the catalytic sensor.

Appendix: PU-Z-054-ENG Ro2



Parameters of gas detectors with electrochemical sensor

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3.5 Influence of vibrations, impacts	
4 Factors shortening the lifetime of the sensor	5

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1 Detected substances

Detectors equipped with electrochemical sensors are used for measuring and detecting the presence of specific substances in gaseous atmospheres in concentrations generally above single "ppm," but in some cases (e.g. oxygen, hydrogen), the concentration may be tens or hundreds of thousands "ppm".

These gases have characteristic measurement ranges. Most of the detected substances are primarily volatile inorganic compounds. Some organic compounds, such as ethylene, ethylene oxide, may also be detected. Table 1 presents an example list of substances detected by electrochemical sensors.

Name of the substance	IUPAC name	Molecular formula	CAS
Oxygen	Oxygen	02	7782-44-7
Ozon	Trioxygen	03	10028-15-6
Hydrogen	Hydrgen	H2	1333-74-0
Ammonia	Azane	NH3	7664-41-7
Arsine	Arsenic trihydride, Arsane	AsH3	7784-42-1
Carbon monoxide	Carbon monoxide	СО	630-08-0
Chlorine	Chlorine	CI2	7782-50-5
Chlorine dioxide	Chlorine dioxide	CIO2	10049-04-4
Ethylene oxide, epoxyethane	Oxirane	C2H4O	75-21-8
Formaldehyde	Methanal	НСНО	50-00-0
Hydrazine, diamine, diazane	Hydrazine	N2H4	302-01-2
Hydrogen chloride	Hydrogen chloride	HCI	7647-01-0
Hydrogen cyanide, Prussic acid	Formonitrile, Hydridonitridocarbon	HCN	74-90-8
Hydrogen sulfide, Sulfane	Hydrogen sulfide	H2S	7783-06-4
Nitric oxide	Oxidonitrogen	NO	10102-43-9
Nitrogen dioxide	Nitrogen dioxide	NO2	10102-44-0
Phosgene	Carbonyl dichloride	COCI2	75-44-5
Silane	Silane	SiH4	7803-62-5
Sulphur dioxide	Sulphur dioxide	SO2	7446-09-5
Ethylene	Ethene	C2H4	74-85-1
Tetrahydrotiofene (THT)	Thiolane	C4H8S	110-01-0

Table 1: Substances detected by the electrochemical sensors

2 Principle of operation

Electrochemical sensors are micro fuel cells. Figure 1 shows a simplified structure of an electrochemical sensor.

The sensor inlet (1) is protected with anti-condensation membrane (6) which serves also as a protection against dust. The simplest electrochemical sensor consists of two electrodes: sensing (2) and counter (3), separated by a thin layer of electrolyte (4). Depending on the detected gas, the reduction or oxidation reaction occurs on the first electrode, which is balanced by a counter electrode by water oxidation or oxygen reduction respectively. In order to improve the performance of the sensor, a third electrode – the reference electrode – is used (5). It has a constant potential that is not dependent on the concentration of the measured gas. Owing to electrode reactions, electrons are generated, whose orderly flow – electric current, is proportional to the concentration of the detected gas.



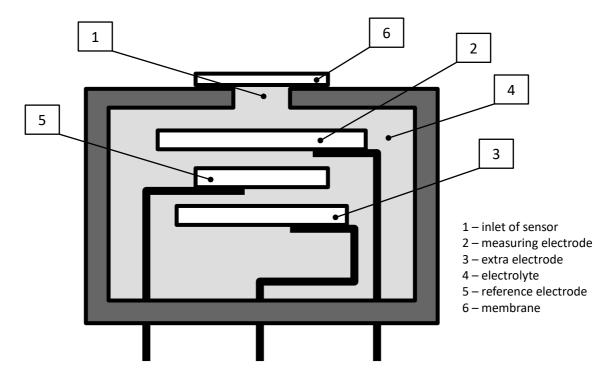


Figure 1: Construction of an electrochemical sensor

Example response to a carbon monoxide sensor: Sensing electrode: $CO + H_2O -> CO_2 + 2H^+ + 2e^-$ Counter electrode: $\frac{1}{2}O_2 + 2H^+ + 2e^- -> H_2O$

Overall reaction: $CO + \frac{1}{2}O_2 \rightarrow CO_2$

3 Impact of environmental conditions



Never exceed the rated operating parameters of the detector. These parameters can be found in the "detector calibration certificate".



The detector must be used in accordance with the provisions in the User's Manual.

3.1 Composition of the controlled atmosphere

It is assumed that the standard composition of the atmosphere is a mixture of gases with the proportions indicated in table 2.



Ingredient	C [% vol]	C [ppm]
Nitrogen	78.084	780 840
Oxygen	20.946	209 460
Argon	0.934	9 340
Carbon dioxide	0.0360	360
Neon	0.00181	18.18
Helium	0.00052	5.24
Methane	0.00017	1.70
Krypton	0.00011	1.14
Hydrogen	0.00005	0.50
Xenon	0.000008	0.087

Table 2: Typical composition of atmospheric air

When gas concentrations in the atmosphere differ significantly from those indicated in the table 2, it is necessary to conduct the analysis of the impact of such a situation on the detector operation.

This publication assumes that the detector is operated under a standard formulation.

3.1.1 Impact of the presence of a substance in a controlled atmosphere

The electrochemical sensor is relatively selective. This means that in addition to the "working gas," that is the one which the detector responds to, these sensors also respond to a relatively small number of other substances in comparison to other measurement techniques.

Because of the indication, a set of substances exists or can exist:

- to which the sensor responds in plus giving a positive signal proportional to the concentration of a substance (e.g. carbon monoxide on a carbon monoxide sensor, being its "working gas", hydrogen on a carbon monoxide sensor),
- to which the sensor responds *in minus* giving a negative signal proportional to the concentration of a substance (for example, nitrogen dioxide for a sulphur dioxide sensor),
- ✓ to which sensor does not respond (the output signal does not change e.g., nitrogen at a carbon monoxide sensor).

A set of substances exists or may exist for every detector:

- ✓ the ones that are inert to the sensor do not react chemically with the sensor detector element (e.g. nitrogen on a carbon monoxide sensor),
- Ithe ones that react chemically with the detector element of the sensor and do not cause a supernormal degradation of its properties (e.g. sensor working gas),
- the ones that affect the sensor elements and cause temporary or permanent degradation of its characteristics or properties.

Due to the physio-chemical phenomena, for each sensor there may be a collection of substances which interact with the working substance leaving no possibility of reaching the detector elements of the sensor by the working gas (e.g. ammonia dissolves in water vapour). In the case of some substances (e.g. chlorine, phosgene, hydrogen chloride, sulphur dioxide) the operating range of the sensor is low enough so that the gas at these concentrations can be absorbed by water vapour from the atmosphere, or condensed on the elements of the sensor. Thus, it will not be the same one, visible for the detector, as long as its concentration does not reach a sufficiently high value and does not saturate water vapour being on the way to the sensor.

3.1.2 Impact of the presence of a working gas or other reaction gas

The reaction of gas from the detector element of the sensor causes its wear, therefore, detectors equipped

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with electrochemical sensors are designed to measure and detect the short-term presence of certain gases in the atmosphere. Both the more sustained concentration with values falling within the range of measurement, and even instantaneous concentrations outside the measuring range lead to a rapid wear of the sensor.

3.1.3 Effect of oxygen concentration value

Depending on the sensor, oxygen is required in most cases for the electrochemical reaction. For a short period of time, oxygen dissolved in the electrolyte is sufficient, however, constant operation in an oxygen-free atmospheres is generally impossible.

3.2 Influence of temperature

The temperature of the measured atmosphere affects the characteristics of the sensor. Its influence in the work of the sensor is compensated electronically.

Very rapid changes in air temperature in the rated temperature range of the detector can cause the sensor responses to this phenomenon.

Rapid reduction of temperature can cause a rapid increase in relative humidity, and thus the reaction of the sensor.

3.3 Influence of moisture

- Depending on the sensor, water is necessary for the electrochemical reaction because the sensors cannot operate in an atmosphere with a low relative humidity. Working in such conditions may lead to the excessive concentration of the electrolyte, which is corrosive and can cause damage to the sensor.
- When the humidity of the measured atmosphere is within the rated range of the detector operation, it does not affect the reading. However, sudden, abrupt changes of humidity in the measured atmosphere can cause momentary appearance of the signal despite the lack of working gas in the vicinity of the sensor.
- It is necessary to consider phenomena making the working gas react with moisture in the atmosphere, not allowing it to reach the sensor (vapours of ammonia, chlorine, hydrogen chloride, phosgene, etc.).
- Condensation may block the flow of working gas to the sensor.

3.4 Influence of pressure

Sudden change of pressure in the presence of working gas can cause an incorrect indication of the detector proportional to the speed and volume change of pressure.

3.5 Influence of vibrations, impacts

It should be ensured that the detector is not exposed to shock and vibration in excess of the amplitude of vibrations amounting to 0.15 mm of the frequencies of over 10 Hz.

4 Factors shortening the lifetime of the sensor

The lifetime of the sensor is limited due to the gradual wear of the electrolyte and electrodes. This time can be significantly reduced as a result of:

long-term persistence of concentrations with the values falling within the range of measurement,

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- the temporary presence of concentrations substantially exceeding the measurement range,
- impact of extreme humidity (very dry or very humid air),
- too high ambient temperature,
- occurrence of abrupt pressure changes.

Appendix: PU-Z-034-ENG Ro2



Parameters of gas detectors with photoionization sensors PID

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3.5 Influence of vibrations, impacts	
4 Factors shortening the lifetime of the sensor	4



1 Detected substances

Detectors equipped with photoionization sensors are used for measuring and detecting the present gas substances, whose energy of ionization is lower than 10.6 eV. They are mostly volatile organic compounds (VOC).

Examples of VOCs that can be detected by a PID sensor equipped with a 10.6 eV lamp:

- ✓ Aliphatic hydrocarbons e. g. pentane, octane, hexane,
- ✓ Aromatic hydrocarbons e. g. toluene, xylene, benzene,
- alcohols e.g. ethanol, propanol,
- aldehydes, ketones, esters,
- amines, sulphides,
- others, including: aviation fuels, petrol, and some inorganic compounds.

PID sensors can also be equipped in e. g.: a 11.7 eV lamp, which, besides the substances enumerated above, is able to detect such substances as: methanol, acetylene or formaldehyde. This lamp has a very short life span (approx. 1 week).

2 Principle of operation

The principle of operation of the PID sensor is based on the phenomenon of photo-ionization. In the PID sensor, the gas passes through the UV beam generated by the lamp energized by the current source. UV radiation leaves the lamp through the window. The emission of electrons occurs as a result of a collision of a photon having a higher energy than the ionization energy of the volatile compound. The voltage between the electrodes causes a stream of positive ions and negative ions that will flow in opposite directions. At that point, a current with intensity proportional to the gas concentration will appear in the circuit. A properly amplified signal will provide information about the gas concentration.

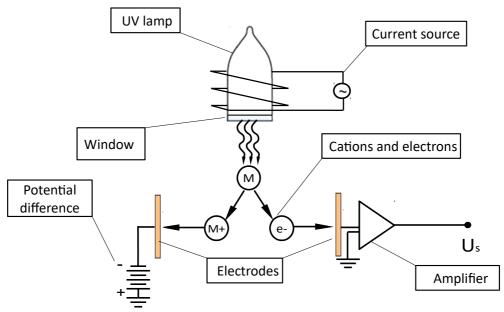


Figure 1: Schematic diagram of the photoionization sensor



3 Impact of environmental conditions



Never exceed the rated operating parameters of the detector. These parameters can be found in the detector calibration certificate.



The detector must be used in accordance with the provisions in the User's Manual.

3.1.1 Impact of the presence of a working gas or other reaction gas

- Some substances may polymerize on the lamp window under the influence of the radiation generated by the UV lamp. This leads to a gradual decrease in sensitivity.
- The persistent presence of high concentrations of the working gas leads to a loss of the sensor's sensitivity. There are solutions available that significantly reduce this effect.
- The photo-ionization sensor is not selective. It reacts to all substances with ionization energy lower than the ones emitted by the lamp, e. g. 10.6 eV.
- The oxygen content in the atmosphere does not damage the PID sensor it can work at any oxygen concentration. However, the value of oxygen concentration in the atmosphere has an influence on the sensor's indication.

3.2 Influence of temperature

Temperature has an influence on the sensor's operation. In the case of specific requirements, this influence can be compensated electronically.

3.3 Influence of moisture

During measurement, water vapour can absorb the emitted radiation, which results in lower sensor sensitivity. This influence can be compensated electronically.

3.4 Influence of pressure

- When there is no reaction gas in the atmosphere surrounding the sensor, pressure changes do not cause a change in the sensor's indications (no effect on the sensor's "zero").
- A change in the absolute pressure can cause changes in the sensor's indications during the presence of the reaction gas in the atmosphere, due to the fact that the sensor sensitivity is dependent on the partial pressure.
- An appropriately high pressure impulse can damage the sensor.

3.5 Influence of vibrations, impacts

Vibrations and impacts affect the sensor's operation. They can cause primarily:

- damage to sensitive parts of the sensor,
- shift of the sensor's zero.



4 Factors shortening the lifetime of the sensor

The lifetime of sensor is limited due lifetime of UV lamp.

The following factors have an impact on the sensor's operation:

- substances that can deposit on the optical elements of the lamp, leading to lower sensitivity (periodic cleaning is therefore required),
- some substances can polymerize under the influence of UV radiation. This leads to lowering the sensor sensitivity,
- the presence of concentrations well beyond the measuring range,
- ambient temperature beyond the range of the environmental parameters of the detector,
- stepwise pressure changes, exceeding the scope of the detector's environmental parameters,
- very dirty atmosphere or with constantly high humidity.



Parameters of gas detectors with Hot-wire sensors

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3.5 Influence of vibrations, impacts	
4 Factors shortening the lifetime of the sensor	



1 Detected substances

Hot-wire sensors are used for measuring and detecting the presence of gases and vapor of combustible substances e. g.:

- / hydrocarbons,
- vapours of alcohol,
- coal gas,
- // hydrogen.

2 Principle of operation

The Hot-wire gas sensor measures the gas concentration by changing the platinum wire resistance by adsorbing gas on the surface of a metal oxide semiconductor. The sensor consists of a sensitive element and a compensating element, which constitute two branches of the bridge. In the case of a flammable gas exposure, the resistance of the sensitive element decreases and the output voltage of the bridge increases in proportion to the gas concentration. The compensation element constitutes a reference and compensates for the influence of temperature.

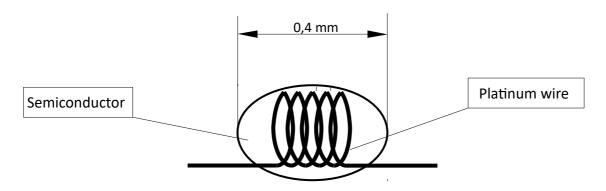


Figure 1: Compensating element construction

3 Impact of environmental conditions



Never exceed the rated operating parameters of the detector. These parameters can be found in the detector calibration certificate.



The detector must be used in accordance with the provisions in the User's Manual.



3.1 Composition of the controlled atmosphere

It is assumed that the standard composition of the atmosphere is a mixture of gases with the proportions indicated in table 1.

Ingredient	C [% vol]	C [ppm]
Nitrogen	78.084	780 840
Oxygen	20.946	209 460
Argon	0.934	9 340
Carbon dioxide	0.0360	360
Neon	0.00181	18.18
Helium	0.00052	5.24
Methane	0.00017	1.70
Krypton	0.00011	1.14
Hydrogen	0.00005	0.50
Xenon	0.000008	0.087

Table 1: Typical composition of atmospheric air

3.1.1 Impact of the presence of a substance in a controlled atmosphere

These sensors combine the advantages and disadvantages of catalytic and semiconductor sensors, react to most combustible gases, but also to chlorofluorocarbons, aerosols and the like. Therefore, the presence of such vapours in the environment may trigger false alarms. Particular attention should be paid to:

- vapours of paints and solvents, oil paints,
- aerosols, perfumes, sprays,
- vapours of spirit, gasoline,
- condensing water vapour.

The prolonged presence of high working gas concentrations causes a decrease in the sensor's sensitivity.

3.1.2 Effect of oxygen concentration value

The concentration of oxygen affects the operation of the sensor. The sensor should operate in an atmosphere of standard oxygen concentration.

3.2 Influence of temperature

The temperature of the measured atmosphere affects the characteristics of the sensor. Its influence in the work of the sensor is compensated electronically.

3.3 Influence of pressure

Within the environmental parameters of the sensor, the influence of pressure on the measurement is negligible.

3.4 Influence of moisture

Excess moisture affects the sensor's sensitivity. If water is condensed on the sensor and it stays on its surface for a long time, a decrease in sensitivity will occur.



3.5 Influence of vibrations, impacts

Strong vibrations and impacts may cause damage of the sensor.

4 Factors shortening the lifetime of the sensor

There are many factors that shorten the life of the Hot-wire sensor:

- / silicone vapors absorb themselves on the surface of the sensor, gradually decreasing its sensitivity (avoid exposure of the sensor to silicone adhesives, silicone latexes, raising agents, oils, greases),
- ✓ high concentrations of corrosive gases (mainly NH₃, H₂S, SO₂, HCl),
- exposure to alkali metals, brine and halogens (mainly fluorine),
- presence of concentrations well beyond the measuring range,
- supply voltage higher than declared in the technical specification of the sensor,
- very dirty atmosphere or with constantly high humidity,
- ambient temperature beyond range of the environmental parameters of the sensor.



Parameters of gas detectors with IR sensors

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3.6 Influence of physicochemical phenomena	
1 Factors shortening the lifetime of the sensor	2



1 Detected substances

NDIR sensors (non-dispersive infra-red sensor), commonly called IR sensors, are used for measuring gases concentrations which have ability to absorb the electromagnetic spectrum in the infra-red range:

- organic compounds particularly methane,
- carbon dioxide,
- ✓ other (e. g. carbon monoxide, nitrogen compounds, ammonia, CFC, SF₆).

Those sensor do not detect hydrogen.

2 Principle of operation

NDIR sensors operate based on the phenomenon of absorption of infrared (IR) radiation wave of a specified length by specific gases. If there is an appropriate gas in the path of this radiation, it will absorb part of this radiation. The sensor consists of a source of IR radiation and a detector for measuring its intensity. The measured gas flows between these elements. The decrease in intensity of the IR beam is a measure of the gas concentration.

3 Impact of environmental conditions



Never exceed the rated operating parameters of the detector. These parameters can be found in the detector calibration certificate.



The detector must be used in accordance with the provisions in the User's Manual.

3.1 Composition of the controlled atmosphere

Due to the principle of operation, detectors equipped with NDIR sensors can work in a variety of atmospheres – including those deprived of oxygen.

3.1.1 Impact of the presence of a working gas or other reaction gas

NDIR sensors are characterized by relative selectivity, e. g.:

- / in principle, they will not be selective within the group of organic compounds,
- they will be selective for gases with different absorption energy in the infrared band.

The method of measuring concentrations using NDIR sensors (in particular in relation with organic compounds), is a method alternative to catalytic methods wherever:

- the presence of gas in the atmosphere may be prolonged or continuous,
- there is a need to measure the concentrations above 100% LEL (to 100% of volumetric concentration),
- there is a need to measure the concentration of organic compounds in a low- or zero-oxygen atmosphere,
- there is a need to measure the concentration of flammable gases in the air, but the presence of gases interfering or destructive for the catalytic sensor does not allow the use of catalytic sensors.

Appendix: PU-Z-064-ENG Ro1



The presence of extremely high concentrations of gases other than the working gas (accompanying gases) may prevent the measurement of the working gas concentration – due to the high absorption of the IR radiation by the accompanying gas (e. g. CO_2 in the CH_4 detector).

3.1.2 Effect of oxygen concentration value

Concentration of oxygen in the atmosphere doesn't affect the detector indication.

3.2 Influence of temperature

Within the scope of the sensor's environmental parameters, the influence of slow temperature changes is compensated electronically. However, rapid temperature changes can cause false indications.

3.3 Influence of pressure

- When there is no reaction gas in the atmosphere surrounding the sensor, pressure changes do not cause a change in the sensor's indications (no effect on the sensor's "zero").
- A change in the absolute pressure can cause changes in the sensor's indications during the presence of the reaction gas in the atmosphere, due to the fact that the sensor sensitivity is dependent on the partial pressure.
- An appropriately high pressure impulse can damage the sensor.
- An appropriately high pressure impulse can damage the sensor.

3.4 Influence of moisture

Within the environmental parameters of the sensor the influence of moisture on the measurement is negligible.

3.5 Influence of vibrations, impacts

Vibrations can trigger the so-called microphone effect in the sensor – manifested by the change in the read concentration.

It should be ensured that the detector is not exposed to shock and vibration in excess of the amplitude of vibrations amounting to 0.15 mm of the frequencies of over 10 Hz. Under no circumstances should the peak acceleration exceed the value of 19.6 m/s².

3.6 Influence of physicochemical phenomena

In the case of chemical compounds with high flash point (approx. 50°C and above) it is necessary to remember that in typical environmental conditions (ambient temperature below 40°C), it is unlikely that they will be able to produce atmospheres close to 100% LEL. Particularly in the case of ambient temperatures below 0°C it may occur that achieving measurable concentrations by the catalytic sensor (of 10% LEL) is impossible. Another measurement method is required in this case.

4 Factors shortening the lifetime of the sensor

Liquid or solid contaminants present in the atmosphere may cause erroneous indications of the sensor, and over time, a damage to the sensor by the contamination of its gas path (e.g. water vapor condensed on the optical elements of the sensor will leave the contaminants present in it before the evaporation).

Corrosive gases (mainly NH₃, H₂S, SO₂, HCl), especially in the presence of water vapor, can lead to a physical destruction of the sensor's gas path.



Instructions for removing the lock of a detector with a catalytic sensor

Detectors using a catalytic sensor (more details concerning the sensor – see Appendix PU-Z-054-ENG) are equipped with a system protecting against its damage caused by a gas concentration exceeding the measuring range of the sensor and before entering non-monotonic part of the catalytic sensor characteristics. In the case of occurrence of such a situation, the detector is switched into the lock state. In this state, the detector saves the last value of gas concentration and switches it off to protect the sensor and prevent false indications.

The lock state is signalled on the detector's display and on all devices showing the detector status (e. g. control units). When the lock detector status occurs, the level of gas concentration in the place of the detector operation must be measured with the use of another measuring device. In a situation when the concentration level drops to the value within the measuring range of the sensor, the operator may proceed to removing the lock – see illustration 1. If the lock is turned off, when the gas concentration in the place of the detector operation is beyond the measuring range of the sensor, a permanent sensor damage or a false reading of the concentration can occur, as a result of the non-monotonic characteristics of the sensor.

When the detector is in the inhibit state and the gas overload condition occurs, the detector will also enter the lock mode and it will be visible after the inhibit mode is deactivated.

The method of executing the "Remove the lock" command can be found in the documentation of the control unit that controls the detector. Turning off the power of the detector automatically disables the lock.



Removing the lock on a detector which is in the conditions of concentration above the measuring range can damage the sensor.



Removing the lock on a detector which is in the conditions of concentration over the measuring range can cause its false indication (due to the non-monotonic characteristics of the sensor).

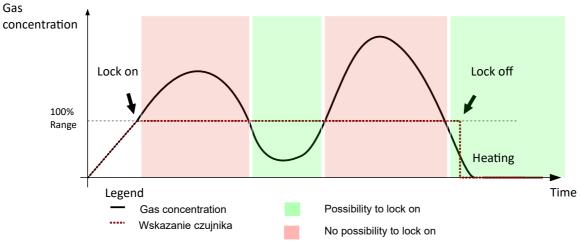


Figure 1: Operation of lock on /off detector



Guidelines to the cabling of the system with an RS-485 interface

1 Introductory



It is recommended that all system components are made according to the design created by person with the necessary skills and competence.

2 Connection cable



The data transmission line for the gas detectors working in the RS-485 standard should be performed only with the use of a shielded twisted pair cable.

In the case where project does not specify this, you can use the following types of shielded cables¹ for connecting gas detectors:

An example of	Approximate outer		
Outdoor installations Indoor installations		diameter [mm]	
YvKSLYekw-P 300 / 300 V 2x2x1	YKSLYekw-P 300/300 V 2x2x1	8.9	
-	LiYCY-P 300 / 500 V 2x2x1	9.5	
YvKSLYekw-P 300 / 300 V 2x2x1,5	YKSLYekw-P 300/300 V 2x2x1,5	10.8	
-	LiYCY-P 300 / 500 V 2x2x1,5	11.7	

It is recommended to:

use cables with a more accurate, round cross-section, made with the use of pressure (better sealing in the Ex glands).

3 Power source



The power supply line should be designed in such a way that, at the lowest expected supply voltage the measured voltage at the gas detector terminals does not drop below the permissible value.

On the side of the power source, the least favourable conditions should be considered. It must be assumed that in failure situation – at the time of power failure – the supply voltage from the battery terminals falls below the nominal value. Please refer to the documentation concerning the uninterrupted power supply (typical minimum supply voltage during operation on an emergency power supply battery is 21 V; below this value the system disconnects).

Different types of insulation may be needed for different locations – e.g. oils, solvents, high temperatures, etc.



4 Power supply of the gas detector

As a standard, in gas detectors with digital data transmission, it is assumed that the voltage cannot drop below 12 V (see the documentation of the detector). The power consumption of the detector is constant within the range of acceptable voltages. With the decrease of supply voltage, the current consumption from the power supply increases.

For example, if the sensor consumes 1 W:

•	when powered by 24 V, the supply current will be	1 W / 24 V = 40 mA
•	when powered by 15 V, the supply current will be	1 W / 15 V = 67 mA
•	when powered by 10 V, the supply current will be	1 W / 10 V = 100 mA

5 Example – a system with a single sensor

Task: Select the sensor power cable under the following conditions:

Data:

•	power consumption of the sensor:	2 W
•	min. power supply voltage:	24 V
•	min. UPS supply voltage	21V
•	min. permissible sensor supply voltage:	12 V
•	distance between the control unit and the sensor:	800 m

Calculations:

•	max. current consumption of the sensor:	2 W / 12 V = 0.167 A
•	permissible voltage drop on the line:	21 V – 12 V = 9 V
•	maximum allowable line resistance:	9 V / 0.167 A = 54 Ω

Cable selection:

- cable with the cross-section of 0.5 mm²: $R(2x800 \text{ m}) = 36 / 1000 * 1600 = 57.6 \Omega > 54 \Omega$ The cable has a resistance greater than the maximum permissible line resistance, so it does not meet the requirements and cannot be used in the system.
- cable with the cross-section of 1.0 mm²: $R(2x800 \text{ m}) = 18 / 1000 * 1600 = 28.8 \Omega < 54 \Omega$ The resistance of the cable is less than the maximum acceptable line resistance – the requirements are satisfied so the cable can be applied to the above system.



The design line can not be longer than 1200 m.



Example of connection cables for gas detector PW-017 and PW-044 with 4-20 mA output

1 Introduction



It is recommended that all system components are made according to the design created by person with the necessary skills and competence.

2 Connection cable

In case where project does not specify this, you can use the following types of shielded cables for connecting gas detectors:

An example of a cable symbol		Approximate external	Maximum cable length
Outdoor installations	Indoor installations	diameter [mm]	[m]
LiYCYv 300/500 V 3x1,0	LiYCY 300/500 V 3x1,0	9,1	155
LiYCYv-Nr 300/500 V 3x1,0	LiYCY-Nr 300/500 V 3x1,0	9,1	155
LiYCYv 300/500 V 3x1,5	LiYCY 300/500 V 3x1,5	9,8	230
LiYCYv-Nr 300/500 V 3x1,5	LiYCY-Nr 300/500 V 3x1,5	9,8	230

It is recommended to use cables with a more accurate, round cross-section, made with the use of pressure (better sealing in the Ex glands).



Example of connection cables for gas detector PW-017 and PW-044 with relay output

1 Introduction



It is recommended that all system components are made according to the design created by person with the necessary skills and competence.

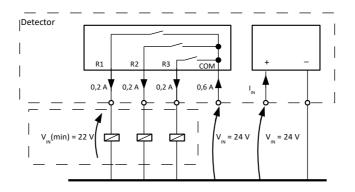
2 Connection cable

In case where project does not specify this, you can use the following types of shielded cables for connecting gas detectors:

An example of a cable symbol		Approximate external	Maximum cable length
Outdoor installations	Indoor installations	diameter [mm]	[m]
LiYCYv-Nr 300/500 V 6x0,5	LiYCY-Nr 300/500 V 6x0,5	10,5	50
LiYCYv 300/500 V 6x0,5	LiYCY 300/500 V 6x0,5	10,5	50
LiYCYv-Nr 300/500 V 6x0,75	LiYCY-Nr 300/500 V 6x0,75	11,3	75
LiYCYv 300/500 V 6x0,75	LiYCY 300/500 V 6x0,75	11,3	75
LiYCYv-Nr 300/500 V 8x0,5	LiYCY-Nr 300/500 V 8x0,5	11,9	100
LiYCYv 300/500 V 8x0,5	LiYCY 300/500 V 8x0,5	11,9	100
LiYCYv-Nr 300/500 V 6x1,0	LiYCY-Nr 300/500 V 6x1,0	11,6	100
LiYCYv 300/500 V 6x1,0	LiYCY 300/500 V 6x1,0	11,6	100
LiYCYv-Nr 300/500 V 8x0,75	LiYCY-Nr 300/500 V 8x0,75	13,0	150
LiYCYv 300/500 V 8x0,75	LiYCY 300/500 V 8x0,75	13,0	150

It is recommended to use cables with a more accurate, round cross-section, made with the use of pressure (better sealing in the Ex glands).

3 Connection relay output





Output current value of the Gas Detector in fault state

Output current	Emergency state
0.25 mA	Data memory error
0.75 mA	Program memory error
1.25 mA	Gas Detector measurement system error
1.75 mA	Gas Detector signal reference system error
2.25 mA	Short circuit in the sensing element supply line
2.75 mA	Break in the sensing element supply line
3.00 mA	Other critical failure
3.25 mA	Temperature measurement system error



The user's interface and failure codes of Gas Detectors of PW-017, PW-044 and PW-093 type

1 Indicator marking symbols

Symbol Description	
	Optical indicator on
O	Optical indicator flashing
O	Optical indicator off
O	Optical indicator status not determined (depends on other factors)

2 Gas detector with FLED display (D=FLED) / FLED.A (D=FLED.A)

In case of use of a detector with FLED four – colour detector status display, information regarding the state of the detector are indicated via colours.

Colour	Description	Acoustic signalling (only for version D=FLED.A)	
- green	The detector works properly	-	
/ - red alternating with green	The first warning threshold is exceeded	-	
- red	Alarm	Modulated sound signal	
openiow - yellow	Detector's critical failure	-	
O- white	Test, calibration	-	

3 Gas detector with LCD display (D=LCD)

3.1 Description of detector state indicators

Indicator	Colour	Description
1	ed - red	The first warning threshold is exceeded
2	e red	The second warning threshold is exceeded
ALARM	e red	The alarm threshold is exceeded
FAILURE	- yellow	Detector's failure
MEASUREMENT	- green	The detector works properly (detector's operation status)
↑	- red	Gas overload

The display has light-sensitive area, which ensures appropriate backlit of the display during operation in an unlit room.



3.2 Detector's state signalling - gas alarms

Situation	Description	Indicators/display ¹
No danger	The detector works properly, measures the concentration, which is indicated by continuously lit MONITORING indicator.	1 2 ALARM 0,0 ppm FAULT MONITORING O
Warning 1	The gas concentration exceeds the first warning threshold. Indicator 1 in the panel is continuously lit. The detector performs measurement, which is indicated by continuously lit MONITORING indicator	1 2 ALARM 10,0 ppm FAULT MONITORING 1
Warning 2	The gas concentration exceeds the second warning threshold. Indicator 1 and 2 in the panel are continuously lit. The detector performs measurement, which is indicated by continuously lit MONITORING indicator	1 2 ALARM 20,0 ppm FAULT MONITORING 1
Alarm	The gas concentration exceeds the alarm threshold. Indicators 1, 2 and ALARM in the panel are continuously lit. The detector performs measurement, which is indicated by continuously lit MONITORING indicator	1 2 ALARM 40,0 ppm FAULT MONITORING
Overload	The gas concentration exceeds the overload value. Indicators 1, 2 and ALARM and 1 in the panel are continuously lit. The detector still performs measurement, which is indicated by continuously lit MONITORING indicator The display shows HH_RANGE information.	1 2 ALARM 42,7 ppm HH_RANGE FAULT MONITORING
Lock ²	The gas concentration exceeds the overload value. Indicators 1, 2 and ALARM and 1 in the panel are continuously lit. The detector is in a locked state – the last value of concentration has been latched. The detector does not measure – MONITORING indicator is turned off. The display shows LOCK information.	1 2 ALARM 110 %LEL LOCK FAULT MONITORING

¹ Display description contains sample content.

² The state occurs only in case of detectors with a catalytic sensor. The lock mechanism is active.

Appendix: PU-Z-073-ENG Ro3

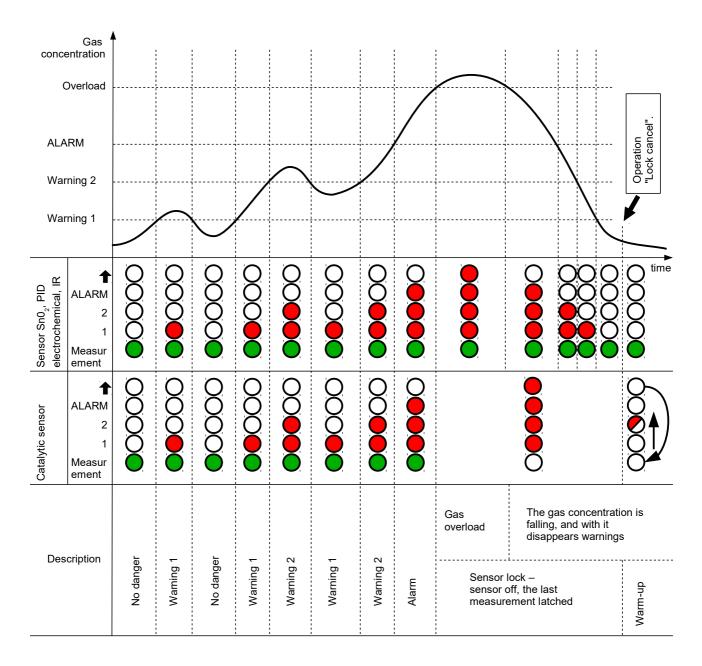


3.3 Detector's state signalling – special states

Situation	Description	Indicators/display
Heating	Preparation of the detector to work. Its indications are ignored. The indicators are lit one after another in the clockwise direction. The display shows message Warm up.	1 2 ALARM S/N XXX Warm up FAULT
Calibration	The detector is in calibration state – its indications are ignored. MONITORING indicator flashes evenly. The remaining indicators are turned off. The display shows message Cal.	O,0 ppm Cal. FAULT MONITORING 1
Test	The detector is in test state — its indications are simulated and all signals are treated as real. Gas alarms and failures are possible. MONITORING indicator — two flashes per 2s (1 2 ALARM 0,0 ppm TEST FAULT MONITORING 1
Non-critical failure	Detector malfunction that may negatively impact its measurement accuracy (e.g. exceeding of time until periodic calibration or small zero drift). The detector still performs measurement. FAULT indicator flashes evenly.	1 2 ALARM 0,0 ppm FAULT MONITORING 1
Critical failure	The detector is damaged and does not perform measurement. "FAULT" indicator is lit continuously, the remaining ones are turned off. The display shows AWK2100H message.	O O D O ALARM 0,0 ppm AWK2100H FAULT MONITORING O



3.4 Signalling depending on the concentration of gas measured by the detector



Appendix: PU-Z-073-ENG Ro3



3.5 Failure codes

Message	Description
AWK <failure code=""></failure>	Critical failure – the detector is damaged – does not perform measurements. The failure code is a hexadecimal number, the meaning of particular bits is as follows: bit 1 – incorrect values in the data block bit 4 – negative zero drift bit 5 – damage of the measurement path bit 8 – collective critical failure – active when any AWK bit is active bit 9 – damage of the measurement path bit 10 – damage of the measurement path bit 11 – sensor signal is too high bit 12 – sensor signal is too low bit 13 – damage of the temperature detector bit 14 – damage of the program block bit 15 – damage of the data block
AWN <failure code=""></failure>	Non-critical failure — malfunction of the defector that may negatively impact its measurement accuracy (e.g. exceeding of time until periodic calibration). The failure code is a hexadecimal number, the meaning of particular bits is as follows: bit 8 — collective non-critical failure — active when any AWN bit is active bit 10 — minor negative zero drift bit 11 — temperature overload bit 13 — calibration time is exceeded



Register map of SmArtGas 3 and ProGas Gas Detector

All the data are available in the 'holding registers' (function code 3).

Register	Name	Description	Туре
40001	State_A	Detector status – the definition of bits below	flags
40002	-	Inessential data, can take any value	-
40003	N	Gas concentration A value of 0 corresponds to the 0 concentration, the value of 1000 corresponds to a concentration of the range of the detector	16 bit integer
40004	-	Inessential data, can take any value	-
40005	Sample_Cnt	Sample counter. The value is increased by 1 after each measurement. It takes values from 0 to 255	Total number 16 bit

State_A - detector status. The meaning of the bits is described in the table below.

Bit	Name	Description
0	Collective_W1	Gas concentration is above first warning threshold
1	Collective_W2	Crossing the second warning threshold
2	Collective_AL	Crossing the alarm threshold
3	Collective_CrFail	Collective information about a critical failure
4	Collective_NonCrFail	Collective information about a non-critical failure
5	Gas_Hi_Range	Operation on a coarse measuring channel (for type 2 and 3).
6	Gas_HiHi_Range	Gas overload
7	Sensor_Lock	Lock of the sensor (the last measurement was locked)
8	Calibration	Calibration mode
9	Test	Test mode
10	Warm_Up	Sensor warm-up
1115	-	Inessential data, can take any value



Classification of chemicals used at Atest-Gaz

Because of the need to present a **consistent and high level of maintenance services**, to ensure **the safety of the calibration process** and to **create a basis for a rational calculation of the costs** of this process, Atest-Gaz developed the "Classification of Chemical Substances" described below.

The classification determines the complexity of the calibration process of a particular detector type, consider two criteria:

- stability of the calibration mixture (criterion A):
 - · ease of generate and its stability,
 - ergonomic complexity of operations,
 - required experience and knowledge of the employee performing the calibration,
 - required equipment,
 - environmental requirements for the process (e.g. weather conditions).
- safety / potential hazard generated by the mixture (criterion B).

These both criteria have an impact on the final cost of the calibration services and level of competence required from the employee conducting the calibration.

This classification is applied both by Atest-Gaz and the entities cooperating with it – distributors, authorized service providers and users of the systems.

In the case of calibration with the "crossover" substances, the classification is made in accordance with the substance category that is applied (e.g. for the detector with a PID sensor this substance is isobutylene, i.e. BO AO).

The detector are classified on the stage of offer.

On the next page we present tables showing the above relationships.

Appendix: PU-Z-039-ENG Ro1



Category	Description	Terms of facility calibration
A0	Cylinder gases, stable environment	No precipitations, and no strong winds, and temperature over – 10°C¹. In other cases, calibration at a location that meets the above conditions (necessary to remove the detectors).
A1	Cylinder gases, unstable environment or absorption by the moisture	No precipitations, and no strong winds, and temperature over + 10°C¹, and relative humidity under 70%. In other cases, calibration at a location that meets the above conditions (necessary to remove the detectors).
A2	Gases not available in cylinders can be generated at the relevant facilities	like A1 In other cases, calibration at a location that meets the above conditions (necessary to remove the detectors).
А3	Laboratory calibration	Facility calibration impossible, laboratory calibration only, probably at the manufacturer's. This group also includes conditions resulting from other reasons, e.g. the need for temperature compensation, non-linearity of the sensor, the need for calculation, the use of special tools, etc.

Table 1. Classification of chemicals used at Atest-Gaz. Criterion A: mixture stability

Category	Description	Classification criteria
В0	Safe substances	concentration of flammable components < 60% LEL, and concentration of toxic components \leq NDSCh ² , and oxygen concentration < 25% vol, and tank < 3 dm³ (water capacity) and p \leq 70 atm, or specified liquid chemical compounds, e.g.: glycerol, 1,2-propanediol.
B1	Low-risk substances	concentration of flammable components < 60% LEL, and concentration of toxic components ≤ NDSCh², and oxygen concentration < 25% vol, and tank > 3 dm³ (water capacity) or p > 70 atm, or toxic gases with the concentration of STEL ÷ 15 x NDSCh, or specified liquid chemical compounds, e.g.: petrol, acetone, 1-methoxy-2-propanol.
В2	High-risk substances	inert gases having an oxygen concentration > 25% vol, or flammable gases with a concentration > 60% LEL, or specified liquid chemical compounds, e.g.: styrene, methanol, xylene, toluene, methyl methacrylate.
В3	Extremely dangerous or extremely flammable substances	toxic gases with the concentration of > 15 x NDSCh ² , or specified liquid chemical compounds, e.g.: benzene, formaldehyde, formic acid, epichlorohydrin.

Table 2. Classification of chemicals used at Atest-Gaz. Criterion B: OHS

p. 2/2

Is allowed to perform calibrations at lower temperatures, if they meet the conditions of operation of the detector, e.g. ammonia refrigeration units.

In the absence of determined NDSCh it is necessary to adopt 2 x NDS as a criterion.