ATEST GAZ

User's Manual

Gas Detector

Sigma SmArt / SmArtGas 3

Product code:

PW-044-X

POD-009-ENG R08

Reliable and Innovative Gas Safety Systems

We design, manufacture, implement and support:
Systems for Monitoring, Detection and Reduction of gas hazards

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Comments and objections

- Connection and operation of the detector is allowed only upon having read and understood the contents of this document. Keep User's Manual with the device for future use.
- The manufacturer shall not be liable for any errors, damage and malfunctions caused by improper selection of equipment, faulty installation, or the lack of understanding of this document.
- It is not allowed to perform any repairs or alterations on the device independently. The manufacturer shall not be liable for the consequences caused by such interference.
- Too much exposure to mechanical, electrical and environmental impacts could damage the device.
- It is not allowed to use damaged or incomplete equipment.
- 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.
- The chosen model of a gas detector can be used in Zone 1 and 2 hazardous areas only after the fulfilment of all the conditions listed below. Failure to meet any of these conditions may result in the machine becoming a source of danger. In parallel, the manufacturer reserves the right to void the warranty on the device handled incorrectly.
- The user should familiarize themselves with applicable legislation at the given moment, especially with the rules for the operation of electrical installations in hazardous areas.
- Performing the electrical connections in hazardous areas is allowed only for persons having the necessary knowledge, experience and authority in the performance of electrical installations in hazardous areas.
- All works should be carried out after finding a lack of gas hazards at the installation site.
- Before opening the housing of the device, it is necessary to:
  - disconnect all power sources from the unit,
  - note the correct loosening of the locking screws M3, so that when unscrewing the transmitter cover and head cover the bolt would not damage the threads (see figure 2),
- When assembling the housing and preparing the device into operation:
  - check whether the device is complete and whether there is any damage to mechanical components,
  - properly assemble all the elements of the sensor,
  - tighten the M3 locking screws on the transmitter cover and the head cover (see figure 2),
  - pay attention to the cable inlet completely tightened around the wire,
  - make sure the device is connected to the protective circuit (see section 6.2.2.3).
- Make sure that the device protection feature corresponds to the environmental conditions, and in particular (see the nameplate of the device):
  - the category corresponds to the designated area,
  - the expected ambient temperature is in the Ta range declared by the manufacturer,
  - gases that may appear belong to the temperature class declared by the manufacturer.
- The recommended operating position of the detector is the position of head down. Other positions can significantly compromise the level of IP of the device.

- Painting of the detector, in particular the sinter, is unacceptable.
- In the case of the expected presence of aggressive gases, make sure that the equipment and materials utilized in the construction are suitable for the intended use. Particular attention should be paid to corrosive gases such as HCl, NH_3, H_2S and SO_2.
- Service operations – related to the calibration of the detector – should be carried out by the personnel duly authorized by the manufacturer.

How to use this manual?

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

Symbol	Interpretation
	Optical indicator on
	Optical indicator flashing
	Optical indicator off
	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 Intended use and principle of operation

Gas detectors are stationary devices, designed to detect and monitor levels of toxic gases, explosive gases and oxygen in the ambient atmosphere.

The gas detectors measures the concentration of a given component, and then turns it – depending on the variety (described below) – to understandable signal for other devices of the gas detection the system. In addition to the implementation of the measurement, the detector analyses the value of the measured concentration and may provide information about exceeding the following threshold values:

- warning 1,
- warning 2,
- alarm,
- gas overload (threatening with the sensor damage).

In addition to the above, the gas detector is a self-diagnostic device – and in the case of detection of malfunctions, it informs the user about it.

During operation of the detector twofold irregularities may occur – or those that prevent continued operation of the detector and require immediate intervention of the service (critical failure), or those that are only a symptom – the user should be notified thereof (e.g. by the control unit), in order to plan an overview at a convenient date (non-critical failure, overload).

1.2 Functional properties

Main characteristics

- Variety of detected gases and vapors.
- Wide operating temperature range.
- Ability to perform with a local LCD / FLED display.
- Optional versions of the housing: aluminum or acid resistant steel.

Basic functionalities

- Non-invasive calibration and configuration – the gas detector can be calibrated and parametrized (e.g. the alarm thresholds) in hazardous areas without opening the housing or turning off other parts of the gas detection system (only for RS-485).
- Output signal:
  - SmArtGas 3: RS-485, 4 – 20mA, relay outputs.
  - Sigma SmArt: RS-485.
- Parametrization and calibration without the use of mechanical parts.
- Electronic compensation of the influence of ambient temperature.
- Self-diagnosis function.
- Storing, in the memory of the gas detector such parameters as: substance CAS number, location name, serial number, the intervals between mandatory calibrations, etc.
- No mechanical control elements.

1.3 Gas detector status

Mode	Description
Correct operation	The detector operates properly and makes measurements. The concentration value of the gas being measured does not exceed threshold values and no irregularities in the device operation were detected.
Warning 1	Signalled after exceeding the gas concentration above the specific value.
Warning 2	Signalled after exceeding the gas concentration above the specific value.
Alarm	Signalled after exceeding the gas concentration above the alarm threshold.
Gas overload	Gas concentration has exceeded the overload threshold value. If such is the case, the sensor may be damaged or its sensitivity and shelf-life may be reduced.
Lock[1]	Gas concentration is above the overload value (the default value is 100% LEL). The detector is locked (see appendix [10]) – the last value of the concentration is shut. The detector does not make measurements. It is possible to unlock the condition by means of sending the applicable command from the control unit or from the superior system. ⚠ Removing the lock on a detector which is in the conditions of concentration above the measuring range can damage the sensor.
Warm up	After turning on the detector's power supply, the sensors's working parameters stabilize for some time. In this condition, the detector does not make measurements.
Calibration	In this state the detector allows to change your settings. In the calibration mode it is also possible to examine the detector without raising an alarm (in fact, the behaviour of the system will be determined by the interpretation of the data by the central system). The detector can be switched to this state using the appropriate software tools.
Non-critical failure	Detector malfunction threatening its accuracy of measurement (e.g. time out for periodic calibration).
Critical failure	Faulty detector or no detector.

Table 2: Gas detector status

1.4 Detected gases

Depending on the gas to which the gas detector is intended, the manufacturer selects the type of the sensor (to avoid confusion, it is assumed that the sensor is an element which converts the gas concentration into an electronic signal, and the gas detector is the entire unit).

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

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

1 The condition is present only for the detectors with a catalytic sensor. Active lock mechanism.

1.5 Output signal

Depending on the needs of the user, the gas detector can work with the output circuit configured as:

- RS-485 output

  this is the basic solution recommended by the manufacturer. It allows easy integration with data transmission systems, visualization systems in ACP, industrial controllers. Gas detector with this type of output are marked with 485.

  - Communication through RS-485 interface is implemented according to MODBUS ASCII (SmArtGas 3) and SigmaBus (Sigma SmArt). Applications of other protocols are also possible.
  - For gas detectors with RS485 output, the output signal is digitized. In general, the gas detector status is described by the following variables:
    - the measurement result in a percentage range (number 0 – 100.00%),
    - information of exceeding the alarm thresholds,
    - status words with information about failures, etc.

- 4 – 20 output (applies to SmArtGas 3)

  - standard current signal 4 – 20 mA

  It allows for easy integration of the gas detectors with other automation systems, e.g. with industrial controllers. Gas detectors with this type of output are marked with 4 – 20,

  - values below 4 mA correspond to states of faulty of the sensor (see appendix [13]),
  - 4 mA corresponds to zero concentration of the measured gas,
  - 20 mA corresponds to the concentration corresponding to the declared scope of operation of the gas detector (see appendix [2]) or higher concentrations (saturation of the gas detector),
  - current value for a particular concentration can be calculated with the following formula:

$$I = 4\text{ mA} + 16\text{ mA} * \frac{\text{concentration of gas applied to the gas detector}}{\text{gas detector measuring range}}$$

- contact output (applies to SmArtGas 3)

  it allows the direct use of gas detectors to control executive devices. Detectors with this type of output are marked with CON.

  There are three contact signals which may be used, e.g. in the following way:

  - PK1: Warning 1,
  - PK2: Alarm,
  - PK3: Gas detector failure.

  PK output parameters are described in table 7.

2 Safety

All activities related to connecting detectors, signallers and other system components must be carried out while Control Unit's power supply is off.

Although switching power supply of the Gas Detection System off, there is a possibility that a dangerous voltage can exist on the terminals of the Control Unit. It can originate from another system like for an example ventilation system that uses one of the output pins of Control Unit.

When performing repair, building and maintenance works, secure the device in a proper way.

Before painting the walls, make sure the device is secured.

Before painting the floors, make sure the device is secured.

Before using silicones or silicon-containing materials (paints, glues, sealing etc.), make sure the device is secured.

Do not repair the device's flameproof connections.

2.1 Marking of explosion protection

Marking of explosion protection is contained in appendix [1] (Declaration of Conformity).

2.2 Areas of safe use due to explosion proof performance

The resulting feature explosion proof performance:

- III 2G Ex db IIC T6-T5 Gb allows for operation in zones 2 and 1 being explosive atmospheres caused by gases, vapors or mists, on the surface, while maintaining the following conditions,
- II 2D Ex tb IIIC allows for operation in zone 21 and 22 being explosive atmospheres caused by dust on the surface of the earth.

> The specified temperature parameters relate to the explosion safety. In fact, the operating temperature range can be narrowed down because of the type of the sensor – in particular cases it may not exceed 40°C.

> For detailed specifications, please contact the manufacturer.

In addition, the device meets the requirements of IEC 60079-29-1 Explosive atmospheres Part 29-1: Gas detectors – Performance requirements of detectors for flammable gases.

2.3 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.

2.4 IP class

The degree of IP protection of the installation can be found in the table 7.

2.5 Other conditions of the working environment

When designing the installation, the following factors should be taken into account:

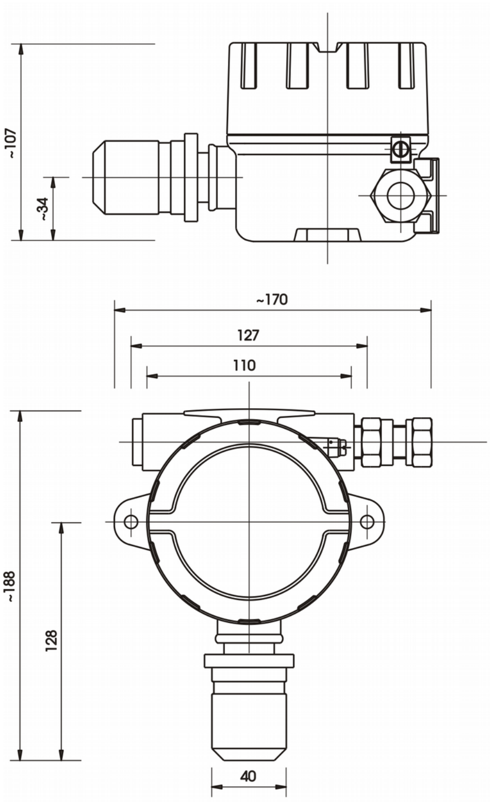
- corrosivity – the device can be installed and used in non-corrosive environments for the materials used. Although appropriately durable materials and corrosion protection was used for the construction of the device, the user or designer should conduct a study of the environmental conditions, taking into account such factors as:
  - the presence of gases such as SO_2, HCl, H_2S, NH_3, and other corrosive ones, especially in humid atmospheres,
  - possible changes in ambient temperature and their relevance to the values declared in this documentation,

  in such situations, we recommend the use of the E = SS option, i.e. in the case of acid resistant steel,

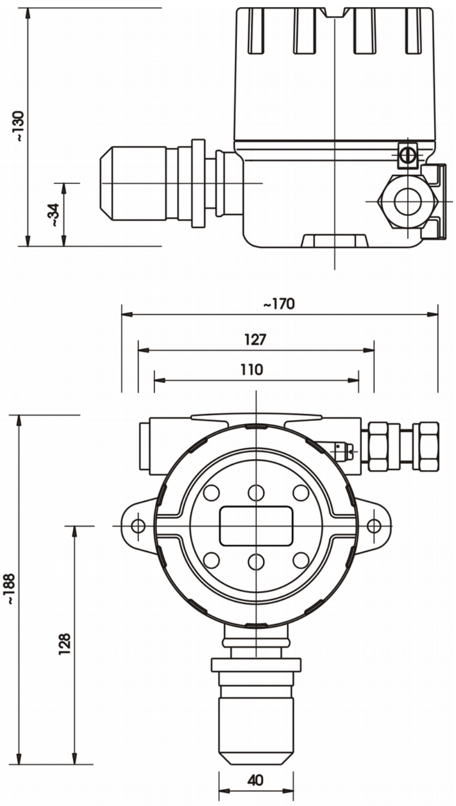
- in the case of reactive substances – such as HCl, Cl_2 – note the danger of adsorption of a particular substance on the sensor surface, particularly in humid environments,
- the probability of deposition of dust, grease and other "clogging" substances, especially on the sinter of the gas inlet to the measuring chamber, which may lead to the inhibit of the detector,
- probability of occurrence of hot vapours of liquid substances at ambient temperature – which constitutes a danger of condensation of this substance on the sensor – as a result, it may lead to the inhibit of the detector,
- ambient temperature – ambient temperature should be in line with the values declared by the manufacturer (or see table 7). Especially during the start-up of the technological installation and in the case of technological failures, attention should be paid to whether there is any temporary exceeding of the temperature range, and when it occurs – please contact the manufacturer,
- if the detector operates at an ambient temperature higher than the maximum permissible ambient temperature, the effect may be twofold:
  - a thermal detector failure can occur, or
  - the detector may become a potential source of ignition for potentially explosive atmospheres,
- danger of flooding the detector with water or other substance – it may lead to the inhibit of the detector,
- when mounting on the outside of the building the detector should not be exposed to direct environmental conditions, it is necessary to apply the relevant water-splash shield or weather housing,
- the oxygen content in the environment – especially in the case of catalytic detector (pellistor type), oxygen content less than 18% significantly reduces the sensitivity of the detector.

  On the other hand, it should be borne in mind that the admission of explosion-proof equipment concerns atmospheres of oxygen concentration up to 21%. In larger concentrations the device loses its explosion-proof properties and can become a source of ignition.
- the presence of other gaseous substances which can cause:
  - false alarms – e.g. the presence of aerosols in the case of semiconductor gas detectors – see appendix [4],
  - pollution of the detector – e.g. the presence of silicone can cause damage to catalytic detector – see appendix [5],
  - crossover effect – the sensor also reacts to other gases, e.g. an electrochemical sensor of carbon monoxide can also react with hydrogen – see appendix [6],
  - masking effect – a reaction of the sensor to the working gas can be reduced in the presence of other interfering gases (e.g. in the presence of nitrogen dioxide, the sensor of sulphur dioxide reacts weaker to the working gas).
- vibrations – may reduce the explosion protection, therefore, in case of such a situation, it is necessary to include appropriate recommendations for more frequent inspections in the project documentation (e.g. more frequent survey inspections of the extent corresponding to visual inspections up close are recommended).

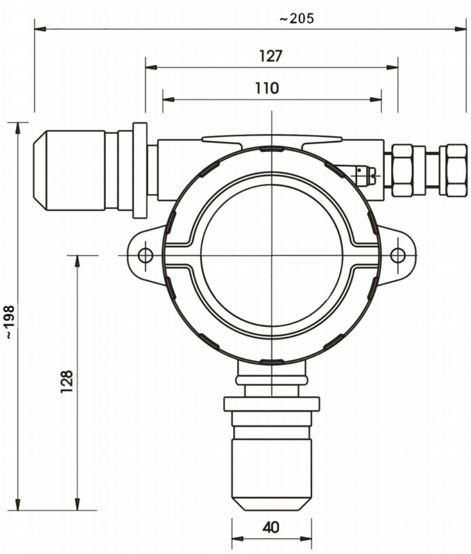
3 Description of the construction



Without display



With display



With acoustic signalling

Figure 1: Device dimension

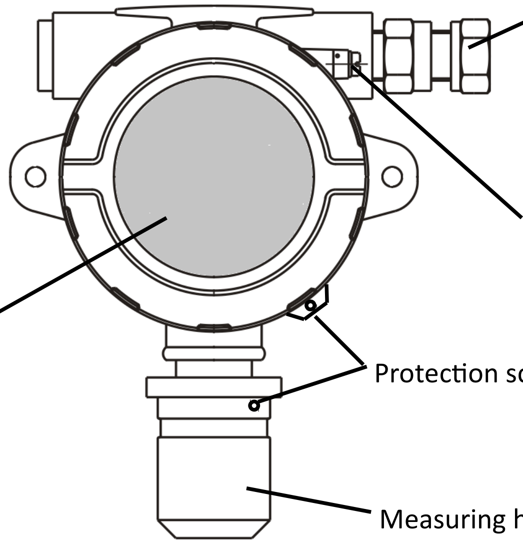


Figure 2: Construction of the device

4 Input-output interfaces

4.1 Output RS-485 (SmartGas 3 and SmArt)

4.1.1 Connection diagram RS-485

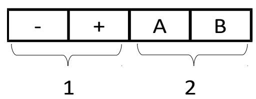


Figure 3: Connection diagram (RS-485)

No.	Name	Terminal	Description
1	Power supply		Power supply port. Parameters – see section 7
		-	Negative supply pole
		+	Positive supply pole
2	SBUS /RS-485		System communication port. Used for data exchange between devices in Sigma Gas system.
		A	Signal line A
		B	Signal line B

Table 3: Connection diagram description (RS-485)

4.1.2 Example of the connection diagram with RS-485 output

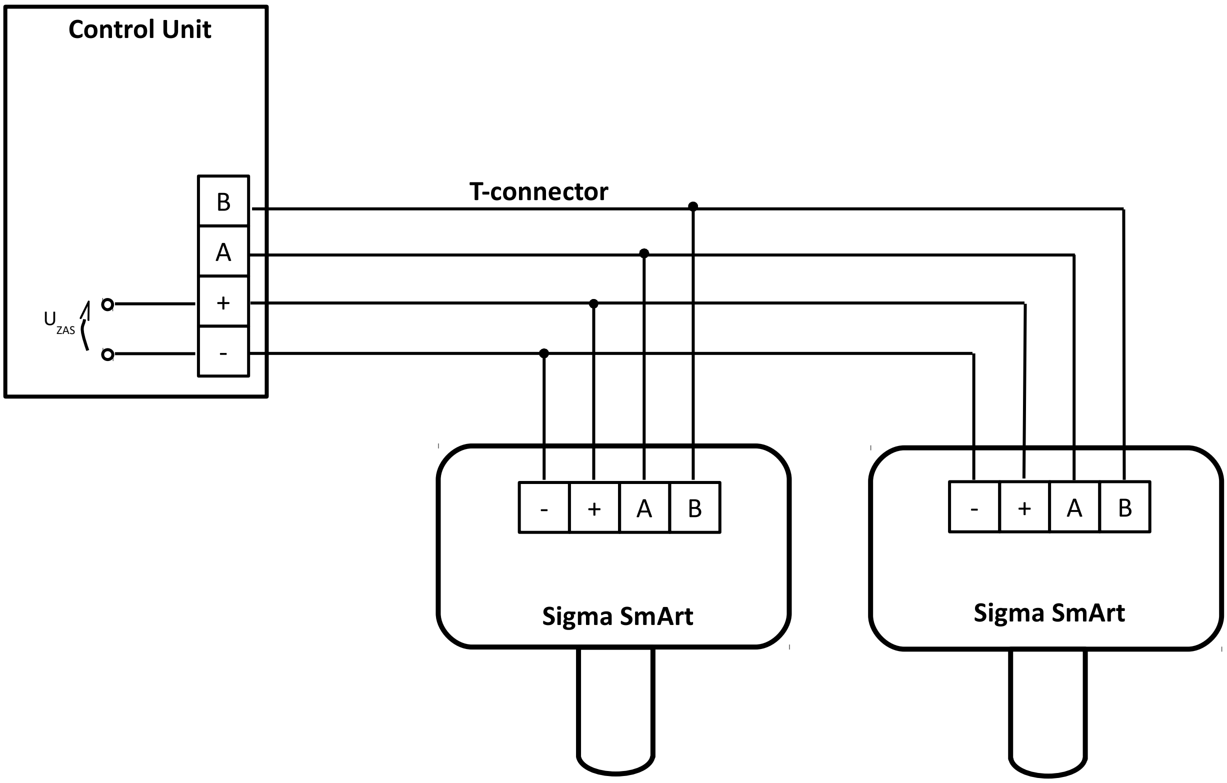


Figure 4: Example of the connection diagram with RS-485 output

4.2 4 – 20 mA (420) output – only SmArtGas 3

4.2.1 Connection diagram 420

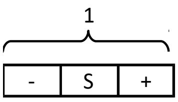


Figure 5: Connection diagram (420)

No.	Name	Terminal	Description
1	Power supply / 420		Power supply port. Parameters – see section 7
		-	Negative supply pole
		+	Positive supply pole
		S	Active current output

Table 4: Connection diagram description (420)

4.2.2 Example of the connection diagram with 420 output

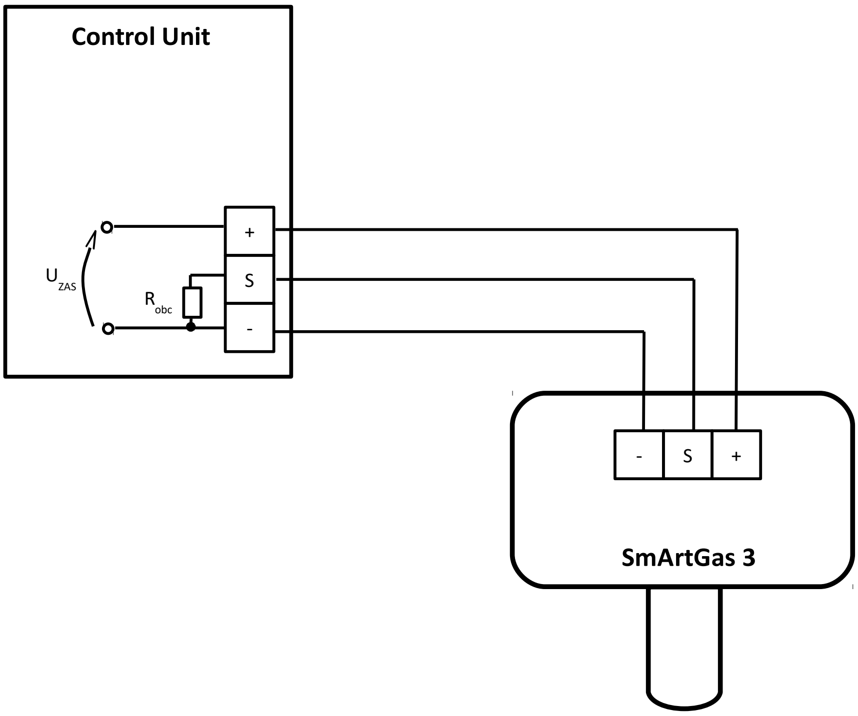


Figure 6: Example of the connection diagram with 420 output

Value of R_{obc} shown in table 7.

4.3 RS-485 + 420 output – only SmArtGas 3

4.3.1 Connection diagram RS-485 + 420

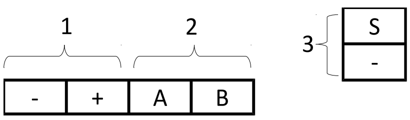


Figure 7: Connection diagram (RS-485 + 420)

No.	Name	Terminal	Description
1	Power supply		Power supply port. Parameters – see section 7
		-	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
		A	Signal line A
		B	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 5: Connection diagram description (RS-485 + 420)

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

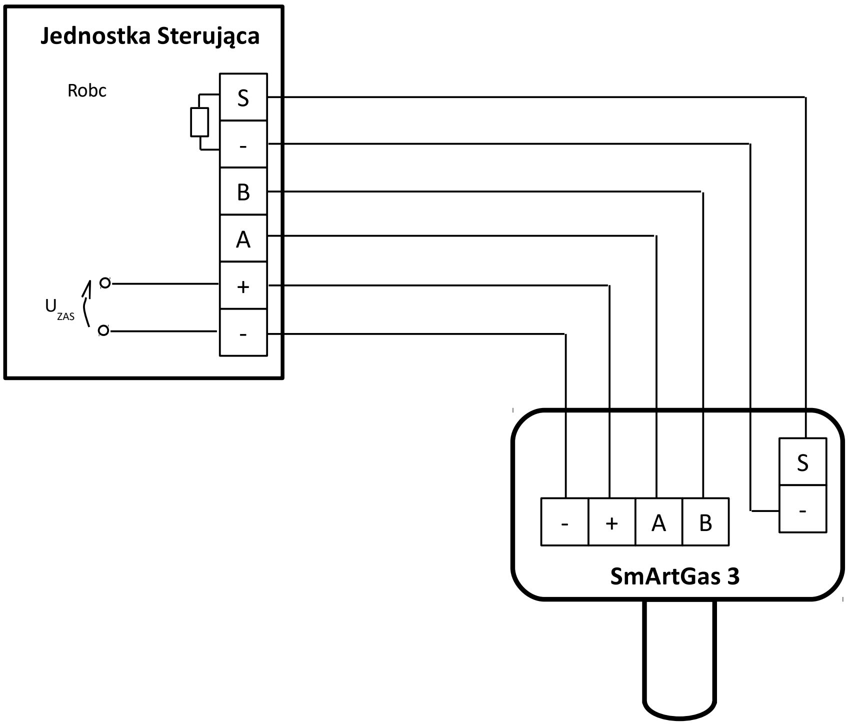


Figure 8: Example of the connection diagram with RS-485 + 420 output

Value of R_{obc} shown in table 7.

4.4 420 + relay output – only SmArtGas 3

4.4.1 Connection diagram 420 + PK

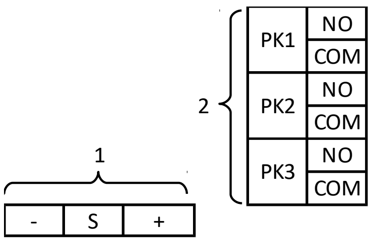


Figure 9: Connection diagram (420 + PK)

No.	Name	Terminal	Description
1	Power supply /420		Device port. Parameters – see section 7
		-	Negative supply port
		+	Positive supply port
		S	Active current output
2	PK1 – PK3	NO	Normally open contact of relay
		COM	Common terminal of relay

Table 6: Connection diagram description (420 + PK)

4.4.2 Example of the connection diagram with 420 + PK output

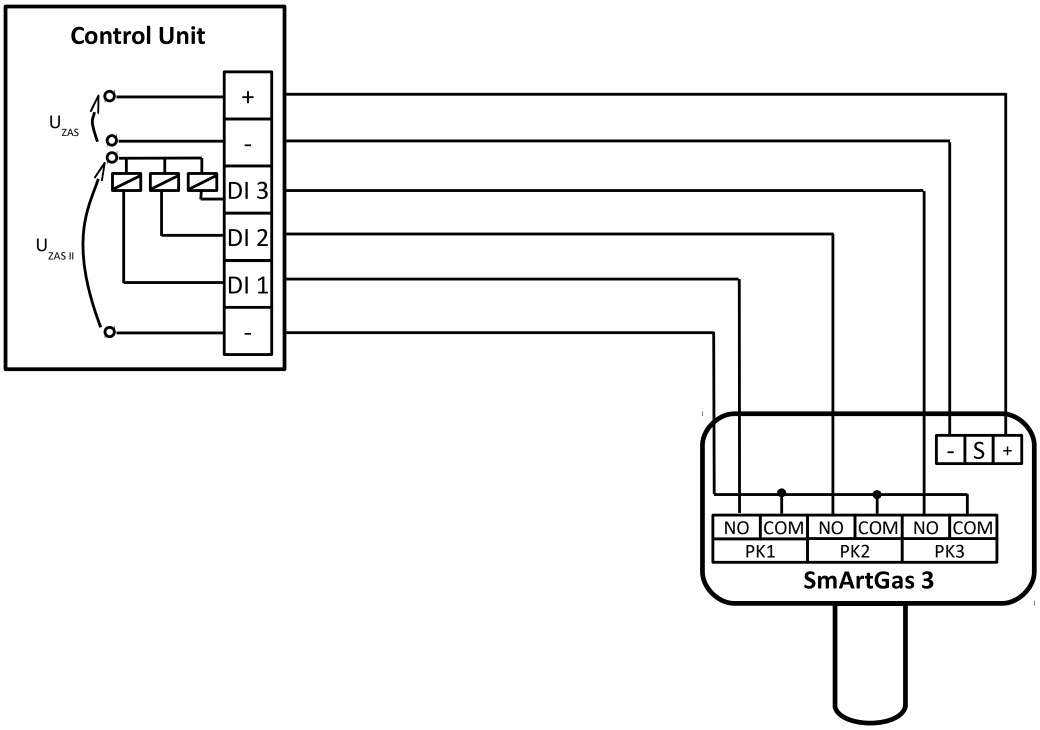


Figure 10: Example of the connection diagram with 420 + PK output

5 User's interface

Detailed description of the user interface are given in appendix [16].

6 Life cycle

6.1 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.

Transport of the device should be carried out under the environmental conditions described in the table 7.

6.2 Installation

6.2.1 Location of gas detectors

The location of detectors should be determined by the system designer, and it should take into account such factors as:

- medium density detected in relation to the density of air – generally light gas detectors are mounted approx. 30 cm under the vault of the facility, and heavy gas detectors approx. 30 cm above the floor,
- the places of the likely accumulation of gas, due to the potential lack of ventilation, or because of the construction of the unit (e.g. a part of the roof cut off by structural elements from other parts),

- the influence of the gas temperature – a substance heavier than air when heated becomes lighter and migrates upwards, but after cooling, it can flow down toward the floor,
- pressure and the expected nature of outflow (leakage / gush),
- volatility of gas – in the case of substances of low volatility, the detector should be located as close as possible to the expected leak,
- the impact of environmental conditions – detectors should not be exposed to the direct impact of water or other chemicals, e.g. cleaners during cleaning of the facility. In particular, care must be taken to prevent flooding / contamination of the steel sinter, since this will lead to the loss of the measuring performance of the detector,
- the detector should also be protected from direct exposure to dust, sunlight, rain and wind. When installing the detectors directly outdoors, it is necessary to use suitable water-splash shield or weather housing. The detector should not be exposed to direct environmental conditions,

  Failure to follow these rules leads to the damage of the sinter or the sensor.
- direction of ventilation – the detectors should be located in areas in the ventilation path from the place of leakage to the extraction unit. In the event that the route may be variable, four detectors should be provided so as to "circumnavigate" a potential source of emissions. In the case of outdoor installation, it is necessary to take into account the expected direction of the wind,
- likely whereabouts of the people in relation to emission sources – detectors should "fence off" the personnel from the source,
- mechanical shock – the detector is made in high strength aluminium casing, resistant to very high mechanical shocks. However, it is necessary to protect the detector from damaging exposures. In the case of damage, especially the surface of flameproof connectors, threads and sinter the detector must be turned off to protect cables and it is necessary to contact the service.

  This requirement must be absolutely respected for equipment operating in potentially explosive areas.
- access – the location should make it possible to perform checks and detector adjustment as well as its replacement or disconnection. When selecting the measuring point, it is necessary to take into account the subsequent development that will hinder the works carried out at the detector on a facility (e.g. the walls, shelves, ventilation ducts, etc.).

6.2.2 Installation and connection

6.2.2.1 General principles

- Select detectors in terms of explosion safety.
- Design the supply installation and data transmission installation of the detectors in hazardous areas.
- Implement the supply installation and data transmission installation of the detectors in hazardous areas.
- Conduct a handover inspection.
- Perform periodic inspections and maintenance.
- The designer, contractor, maintenance person and other interested persons should consult the full content of the regulation and properly use it.
- The manufacturer shall not be held responsible for the design, construction, operation and maintenance of the system.

6.2.2.2 Mechanical installation of the detectors

The detector must be mounted with the detection element down, using the two mounting holes, with the use of two expansion plugs or M5 screws.

The detectors are optionally provided with a mounting base, allowing to mount a detector at a certain distance from the wall (e.g. in the case of uneven walls). As a result, we gain the opportunity to make a water-splash shield to the head and prevent the accumulation of moisture on the detector, in case water is running down the wall (see section 3).

6.2.2.3 Electrical installation

Electrical power supply installation of the detectors working in hazardous areas may only be performed by persons with relevant qualifications (e. g. licence of the inspector for the Reception of explosion-proof construction devices), or acting in concert and under the supervision of the manufacturer.

The electrical installation must be performed in accordance with the project.

The applied flameproof cable glands allows to introduce cables with diameters of a specific range. The suggested cable types are included in the table in appendix [14].

When performing electrical connections, it is necessary to observe the following order:

- make sure that the connected cables are disconnected from any electrical circuits and potentials,
- make sure that during installation there is no risk of explosion or fire,
- unlock the detector cover by loosening the cover locking screw which is located on the periphery, thereof,
- unscrew the cover of the detector,
- remove the cover of the detector,
- loosen the cable gland,
- after the preparation of the cable (see appendix [15]) insert the cable through the cable gland,

⚠ Make sure that the cable outer diameter corresponds to the type of cable gland.

- properly lay the cable so that it is not influenced by mechanical stress – see figure 11,
- tighten the cable gland,
- tighten the detector cover, making sure that the seal is in place,
- tighten the protecting screw.

As far as the design allows, the cable entry screens should be connected to detector groove, avoiding the introduction of the braid to the inside of the device. Do not connect the screen to the high-power cable of the electronics.

⚠ Ground the detector by connecting the cable (4 – 6 mm^2) to the ground terminal (see figure 11).

Ground connection should be protected from corrosion (e. g. a small amount of technical petroleum jelly).

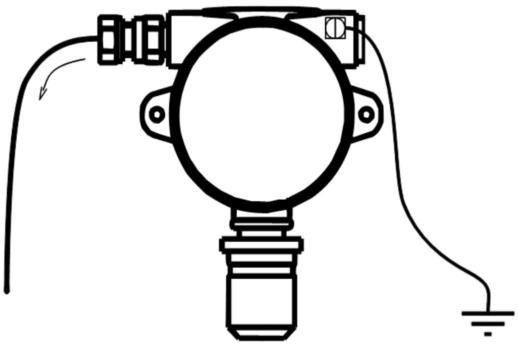


Figure 11: Grounding connection and correct cable laying

The cable shield shall be isolated and slightly protrude from the cable entry inside the detector. The shield cannot be connected to any device point.

A detailed description of the preparation of the cable and connecting the cable to the detector is provided in appendix [15].

On the side of the control unit, screens must be connected to ground.

According to good practice, wiring of the detectors should be carried out as far as possible from the power cables / high-current cables, preferably in separate trays.

Installation of a gas detection system is not intrinsically safe. Damage to the cable is dangerous.

If the connection was made with the use of multi-wire cables (commonly known as a "cord"), the ends of these connectors should be ended with clamp sleeves.

If there is a need to connect two conductors in one terminal of the device, the only allowable option is to connect them in a common clamping sleeve.

It is unacceptable to combine in one connector two wires which are not pinched in one cable lug.

Do not place the cable reserve in the device. Bare wires or wires surplus may create a danger of electric shock or equipment damage.

Do not leave disconnected cables inside the device.

> Incorrect cable routing can lead to reducing the device's immunity from electromagnetic interference.

6.3 Start-up of the installation

6.3.1 Overview of explosion safety

Only after a positive assessment of the method of connection and restoring flameproof properties of the detector, it is permissible to connect the detector to power and the transmission line.

6.3.2 Handover inspection

The handover inspection should provide for the examination of the detectors and checking the whole alarm track for each detector.

The handover inspection should include suggestions as to the date of the first survey inspection. The date of the first survey inspection should be no longer than 6 months (the period of 3 months is recommended).

6.3.3 Commissioning of the gasometric installation

- It is recommended that – if possible – the commissioning of a gasometric installation should take place in conditions where there is no risk of explosion – e.g. during a standstill of the technological installations. However, if this is not possible, it is necessary to observe all the rules relating to the safe handling of electrical equipment in hazardous areas.
- In the case of large installations, it is recommended to successively connect detectors and their gradual start-up. This makes it easier to find and remove any installation errors.
- The behaviour of the detector after being powered and its operation are described in subsequent sections of this documentation.

After wiring of electrical connections and their admission to commissioning, the installation is ready for operation.

6.4 Periodical operations

This description applies to the principles of operation of gas detectors after they have been installed correctly (see section 6.2.2) and after commissioning inspection and the commissioning of the installation (see section 6.3).

During the operation of the gasometric system, it is necessary to be aware of the fact that the detector – and most of all the sensors – are elements susceptible to aging and environmental influences. Therefore, the maintenance process must be carried out systematically. In general, it applies to two aspects:

- changes in the characteristics of detectors,
- maintaining the technical condition guaranteeing explosion proof performance (flameproof) of the installation.

Changing the characteristics of the detectors may in turn relate to three issues:

- moving the clock – towards the concentrations of positive or negative nature,
- changes in sensitivity,
- increasing the response time – as a result for example of the sinter contamination through which the gas migrates to the detector.

6.4.1 Activities connected with the operation

Activities connected with the operation of detectors can be divided as follows:

- verification – feeding the gas at a control concentration in order to validate the detectors response,
- 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 the gas at a control concentration and clean air, in order to correct the processing characteristics.
- inspection – overall assessment of the technical condition of the detector, especially for the state of explosion protection,
- maintenance – activities aimed at the preservation or restoration of the technical condition that allows continued operation (includes the explosion-proof construction).

All of the above steps can be carried out only by trained professionals, in accordance with the art, the general safety rules and the special conditions of installations that should be included in the form of appropriate procedures applicable in the plant.

The investor or persons indicated by them, responsible for safety in the plant, define the services allowed to perform manual detector operation as above and the scope of work assigned to them (i.e. the whole maintenance or breakdown into tasks).

6.4.2 Principles of safe operation of the detectors

- Persons carrying out relevant activities should have appropriate qualifications:
  - checking – operational service, manufacturer training,
  - calibration and adjustment – the manufacturer's service.
  - inspection, maintenance – the manufacturer's service.
- Do not carry out any work where gas is expected to be a threat.
- If despite the expected hazardous gas, it is necessary to disconnect the detectors, it is required to maintain replacement measures by, for example, properly positioned portable detectors.
- Conducting replacement measures is recommended in each case connected to the restriction of the operation of the basic detection system.
- The process of verification / calibration / adjustment should be well prepared and take as short as possible.

6.4.3 Calibration

- Checking of the detectors is carried out without their dismantling (in explosive areas even without opening the housing). In some cases, it may be necessary, however, to mount the sensor to check – applies to detectors having no 485 communication and detectors for the specific media (some higher hydrocarbons).

- Checking is done by giving the test gas at a concentration of about 20% higher than the value of the alarm threshold – or at 50 – 100% of the measurement range and monitoring the behaviour of the detector.

  The gas is provided from the respective cylinder / bag using a calibration cap screwed onto the measuring head. In some cases, it is necessary to use the respective gasometric syringes, simulating the diffusion propagation of gas (e.g. in the case of phosgene). The detector suitable for further use should generate an alarm.

  The drift of the characteristics of the detector can be twofold:

  - towards negative concentrations (loss of sensitivity) – providing the test gas allows to detect a loss of sensitivity greater than 20% of the preset value. According to the rules specified hereafter, if no alert is generated after providing the test gas, it means the need for recalibration and adjustment,
  - towards positive concentrations – the drift is tantamount to lowering response thresholds of the detector and is detected by observing its current indications. Even in the absence of observation, when the drift exceeds a predetermined value, the detector signals exceeding the first threshold alarm,

    Since during the operation, the detector can also indicate the presence of a background (pollutants), in justified cases it is recommended to check the zero by clean air where its indications have reached alarming value (e.g. 50% OEL) – in order to check whether the indication is derived from the existing contamination or whether it is caused by drift characteristics.
- Regardless of the emerging alarms, we recommend observing the actual detector measurements – in systems that make this possible.
- The installed calibration function in the detectors allows you to see the indications without generating system alarms, so the check is not equal to alarming the environment. It is recommended, however, at the time of each review, to verify the whole alarm track – from detector to actuator, at least for some detectors (during the handover inspection of – for all detectors).
- Detectors are switched to the calibration mode using the appropriate functions of software tools.
- The detectors must be switched to the calibration mode individually or in groups. It is convenient to conduct this process in a team of at least two, ensuring communication between the dispatcher and the operator for example by using a radio.
- In the case of extensive systems, it is suggested to carry out checking in cycles – assuming that every day only a specific group of detectors is subject to checks; e.g. the sensors at the facility can be grouped in a checkerboard pattern, which actually increases the efficiency of the check.

6.4.3.1 Calibration of the detectors – general principles

Calibration should ensue:

- due to a negative result of the checking of the detector, or
- after the environmental overload of the detector,
- no less frequently than: (depending on the facility):
  - for catalytic detectors: every 3 – 12 months,
  - for electrochemical detectors: every 6 – 12 months,

- at other time interval determined on the basis of the survey inspection and changes in sensitivity during the operation in the plant.

Detectors calibration should be carried out in a laboratory under the fume hood (manufacturer's recommendation).

When for certain reasons disassembly is not possible, it is permissible to conduct the calibration "in situ", i. e. without removing the detectors.

A decision in this case belongs to the investor (or their designated person / persons responsible for safety at the plant) under their responsibility.

After the adjustment process, it is necessary to conduct rechecks of detectors, in order to hedge against potential errors during the adjustment.

The detector calibration occurs digitally. It involves connecting a PC (e. g. a notebook) to:

- detector data bus – in versions with RS-485 – in those versions, a common data bus transfers data between detectors located in the zone and the central alarm panel always located outside the explosion hazard area. The service device is connected to the bus already outside the zone,
- directly to the detector: when you open the cover – in versions without display (allowed only for detectors located outside the zone).

The following calibration methods are available:

- laboratory method – removal of detectors and securing cables so that they present no danger in explosive areas, then laboratory calibration in the fume hood (manufacturer's recommendation),
- direct method – connect your notebook directly to the detector – calibration "in situ" combined with opening the housing, permissible only for detectors working outside the zone or detectors in the zone – after adequate safety precautions – e.g. during a technological standstill, with explosion hazard control by means of an independent explosion meter and after appropriate consultation with the owner of the installation,
- remote method – connect your notebook to the data bus of the system, outside the potentially explosive atmosphere. Method recommended by the manufacturer.

  The main advantage of this method is that during calibration it is not necessary to perform any mechanical operations on the detectors (such as the opening of the housing) – with the exception of screwing the calibration caps and the gas feed. This method also allows the simultaneous analysis of data by the system manufacturer, provided that a methods of remote data transmission is applied – the web, modem, etc.

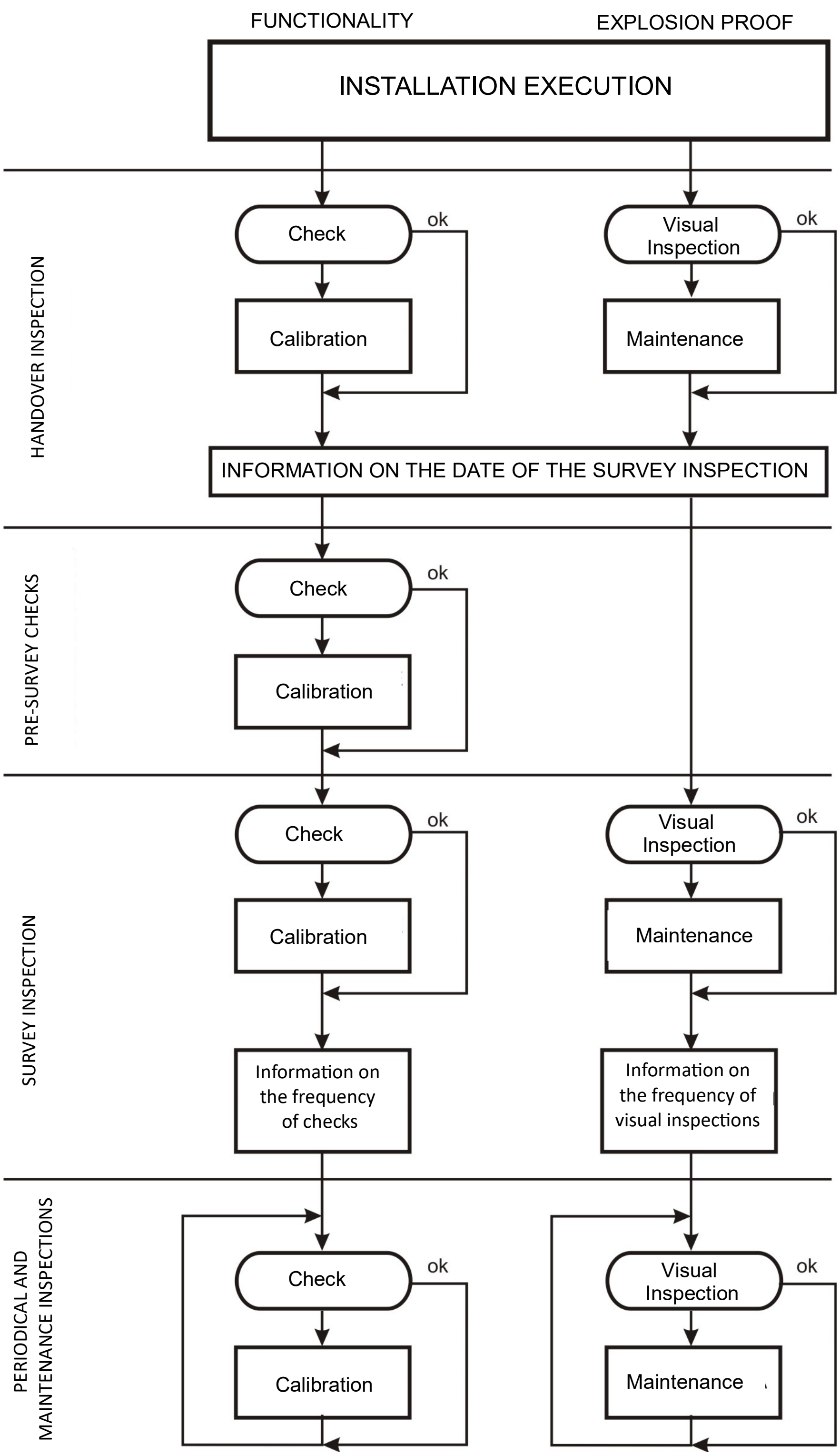


Figure 12: Operation chart of gasometric detectors

6.4.3.2 Calibration procedure

The procedure for calibration / adjustment is based on:

- switching the selected detectors to calibration mode – the calibration mode is recognized by the control unit – it allows it to avoid unnecessary alarming of the environment as the detector responds to the test gas,
- activation of the registration mode in the program,
- subsequent provision of the gas sequence (high concentration / air / high concentration) to the various detectors. Indications of detectors automatically register in the service tool,
- data analysis – entering the correction factors for detectors,
- switching off the calibration mode,
- conducting re-checking of the detectors.

During calibration the following is determined:

- the degree of characteristics drift,
- the degree of sinter contamination (measuring the response time T90),
- the degree of sensor wear,
- the power state of the sensor (if applicable).

Calibration can be performed only by persons specifically authorized by the manufacturer.

6.4.4 Handover inspection – reminder

The manner of conducting the handover inspection is described in section 6.2.2.

Below we remind you of only two key observations:

- the handover inspection should provide for the examination of the detectors and the whole alarm track for each detector,
- the handover inspection should include suggestions as to the date of the first survey inspection. The date of the first survey inspection should be no longer than 6 months (the period of 3 months is recommended).

6.4.5 Checking the detectors before the survey inspection

In certain cases, in the period preceding the first survey inspection, it may be necessary to check detectors – e. g. every two weeks, to determine their behavior. A period of two weeks may be too short to assess e. g. corrosive atmospheres, so checking should not be equated with a survey inspection.

6.4.6 First survey inspection

The first survey inspection is performed for assessing the aggressiveness of the environment in which the installation is situated.

On its basis it is possible to define the cycle of periodic inspections:

- visual inspection of the installation; during this inspection it is also appropriate to check detectors to determine the frequency of subsequent checks,
- checking the detectors,
- checking the alarm track for the selected alarm detectors.

6.4.7 Periodic inspections

Periodic inspections shall include the following:

- assessment of the overall condition, taking into account explosion safety,
- checking of the detectors – checking of the detectors is carried out without their disassembly, by feeding a gas at a control concentration in order to validate the detector's response,
- checking the alarm track for the selected alarm detectors.

The result of the review should be a report providing guidance as to:

- the need to carry out maintenance works,
- the need for calibration and adjustment of detectors.

6.4.8 Inspections arising from the conditions of use

In the case of an increased risk installation, it is assumed that there is a need to check the detectors after each actuation and after every failure of the technology in the plant (which could affect the detector, but does not trigger the reaction of the detectors – e. g. the outflow of hot steam, etc.). The criteria are set individually, through negotiations with the technologists of the establishment, defined as the principles of safe use of the system in the plant, taking into account its specificity and developed by the professionals responsible for the safety of the plant or the processing line. Persons directly responsible for the safe operation of the system should be trained regarding the safety regulations at the plant and required to take appropriate action after the event of a faulty situation.

6.4.9 Ranking of detectors

In the case of extensive installations, for the detectors used, the user should perform adequate "validity ranking". The position of a given detector in this ranking can be helpful in determining the period between checks / calibrations.

6.4.10 Repairs and changes in the installation

They should be made taking into account section 6.2.2, and consultation with the manufacturer.

6.4.11 Recall from operation, periodic disconnection

In the case of a need to recall device from operation (e.g. for maintenance or repairs), observe the regulations of section 6.2.2, as far as possible, in consultation with the manufacturer.

6.4.12 Replacement of consumables

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

6.4.12.1 Sensor replacement

During operation there is a natural loss of metrological parameters of the sensors. Compensation of this phenomenon occurs through periodic, systematic adjustment of the display (see calibration procedure) – until the moment when it is necessary to exchange the sensor. It is assumed that the exchange should be carried out after the loss of sensitivity below 50% of the initial sensitivity.

6.4.12.2 Assembly and disassembly of the sensor in the measuring head

> ⚠ It is recommended that all manipulations with the measuring head were performed by the manufacturer's service or trained personnel. Replacing the sensor must always be connected with the calibration of the detector. Any manipulation must be performed with the detector power off.

To remove the head cover, it is necessary to:

- loosen the locking screw with 1.5 mm allen key.
- grab the gland, do not allow it to rotate (due to the possibility of damage to the connector inside the enclosure),
- unscrew the sensor cover,
- remove the old and install a new sensor in the head, paying attention to the correct setting of the connectors,
- apply a small amount of technical petroleum jelly onto the thread of the gland
- tighten the sensor cover (until resistance is noticed),
- 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 it is necessary to unscrew the gland from the head, first disconnect the strip inside the housing.

6.4.13 Maintenance

6.4.13.1 Basic maintenance tasks associated with maintaining explosion protection

- Maintenance of the flameproof surface and threads using acid free vaseline.
- Checking the status and cleaning the sinters.
- Checking the tightness of cable gland.

6.4.13.2 Replacement of cable glands

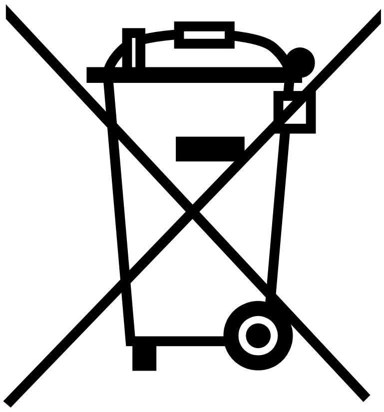
To replace the cable gland you should:

- Unscrew existing cable gland from the equipment,
- apply a non-setting grease on the thread of new cable gland,
- screw in the new cable gland.

6.4.13.3 Cleaning the device

The only manner of cleaning the device is to wipe it with a damp soft cloth. Agents containing solvents, petrol or alcohols cannot be used to clean the detector.

6.5 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.

7 Technical specification

Power supply • V_{CC} • Power consumption	 12 – 30 V ⎓ 0,48 – 3,6 W
Environment • Ambient temperatures • Humidity • Pressure	 -20 – +40°C (option T = 0) -40 – +85°C (option T = T) 10 – 90% long term 0 – 99% short term Without condensation 1013 hPa ± 10% Any of the above parameters can be limited by the parameters of the sensor
ATEX	Ex II 2G Ex db IIC T6-T5 Gb T5: -40 < Ta < 85°C II 2D Ex tb IIIC T6: -40 < Ta < 70°C IEC 60079-29-1
IP	IP63 IP65 (using a Water-Splash Shield PW-071-A)
Analogue output parameters 4 – 20 mA (applies only to SmArtGas 3) • R_{LMAX}	(option O = A / O = D, X = AL) 200 Ω
Digital output parameters (applies only to SmArtGas 3) • Number of relays • Parameters	(option X = PK) 3 Floating contacts 3 x NO/NC, 24 V DC, 0,2 A Not protected against overloading
Digital communication parameters • Electric standard • Communication protocol	 RS-485 • Modbus ASCII 19200 7E1 (PW-044-A-SG) • SigmaBus (PW-044-A-SS)
Integrated signalling equipment (visual)	Alphanumeric display 2x8 of the LCD type with LED indicators (option D=LCD) Multicolor status display FLED (D = FLED, D = FLED.A)
Dimensions	See figure 1
Cable glands • Cable diameter range • External thread	 See appendix [2], [3] M20
Acceptable cables	0.5 – 2.5 mm^2 cable lugs 2 x 1 mm2 or 2 x 0.75 mm^2 should be used for double wires
Enclosure material	• 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) – the time can be shortened because of the difficult working conditions
Mounting	• To the wall, 2 screw holes 4 mm, hole spacing 127 mm • We recommend using mounting brackets PW-064-WM1 / PW-064 -WM2 / PW-064-WM4.

Table 7: Technical specification

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

<table>
<tr><th colspan="5" rowspan="2">Product code</th><th colspan="2">Current consumption [mA]</th></tr>
<tr><th>12 V</th><th>24 V</th></tr>
<tr><td rowspan="15">PW-044</td><td rowspan="15">SG
SM</td><td rowspan="3">TS</td><td>0</td><td rowspan="6">HL</td><td>20</td><td>20</td></tr>
<tr><td>LCD</td><td>45</td><td>35</td></tr>
<tr><td>FLED
FLED.A</td><td>125</td><td>75</td></tr>
<tr><td rowspan="3">EL
ELm
VOC
DET</td><td>0</td><td>100</td><td>70</td></tr>
<tr><td>LCD</td><td>115</td><td>80</td></tr>
<tr><td>FLED
FLED.A</td><td>205</td><td>125</td></tr>
<tr><td rowspan="6">IR</td><td rowspan="2">0</td><td>HL</td><td>80</td><td>55</td></tr>
<tr><td>HH</td><td>155</td><td>95</td></tr>
<tr><td rowspan="2">LCD</td><td>HL</td><td>95</td><td>65</td></tr>
<tr><td>HH</td><td>170</td><td>105</td></tr>
<tr><td rowspan="2">FLED
FLED.A</td><td>HL</td><td>185</td><td>110</td></tr>
<tr><td>HH</td><td>260</td><td>150</td></tr>
<tr><td rowspan="3">PID</td><td>0</td><td rowspan="3">HH</td><td>120</td><td>75</td></tr>
<tr><td>LCD</td><td>145</td><td>90</td></tr>
<tr><td>FLED
FLED.A</td><td>225</td><td>130</td></tr>
</table>

Table 8: Current consumption

8 List of consumables

Consumables	Life time	No.	Manufacturer	Product code
Sensor with gasket	Dependent on sensor type	1	-	-
Flameproof housing	Dependent on environment	2	Atest Gaz	PWS-046-A

Table 9: List of consumables

9 List of accessories

Product code	Device
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[2]	Mounting Adapter WM4
PW-069-DP1	Weather Housing DP1
PW-069-DP1WIN	Weather Housing DP1WIN

Table 10: List of accessories

10 Product marking

Type	Description	Product code
Gas Detector	SmArtGas 3	PW-044-SG-X
Gas Detector	Sigma SmArt	PW-044-SM-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] (SmArtGas 3) and [3] (Sigma SmArt).

2 Mounting adapter can not be used for the version D = FLED.A.

11 Appendices

[1] DEZG019-ENG – EU Declaration of Conformity – Sigma SmArt, SmArtGas 3

[2] PU-Z-052-ENG – Marking the hardware configuration SmArtGas 3

[3] PU-Z-055-ENG – Marking the hardware configuration Sigma SmArt

[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

[8] PU-Z-033-ENG – Parameters of gas detectors with Hot Wire sensors

[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-074-ENG – Example of connection cables for gas detector PW-017 and PW-044 with 4 – 20 mA output

[12] PU-Z-076-ENG – Example of connection cables for gas detector PW-017 and PW-044 with relay output

[13] PU-Z-036-ENG – Output current value of the sensor in fault state

[14] PU-Z-003-ENG – Guidelines to the cabling of the system with an RS-485 interface

[15] PU-Z-015-ENG – Manual for the wiring of PW-044 sensors for cable glands without the possibility of connecting a cable shield

[16] PU-Z-073-ENG – The user's interface and failure codes of Gas Detectors of PW-017, PW-044 and PW-093 type

[17] PU-Z-056-ENG – Register map of SmArtGas 3 and ProGas Gas Detector

[18] 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	**Sigma SmArt, SmArtGas 3**	**PW-044**

complies with the following Directives and Standards:

- in relation to Directive 2014/34/EU – on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres:

Marking	Certificate no.	Standards	Notified body
Ex II 2G Ex d IIC T6-T4 Gb	FTZU 08 ATEX 0005X	EN 60079-0:2012 EN 60079-1:2014	1026 Physical-Technical Testing Institute, Pikartska 7, 716 07 Ostrava-Radvanice, Czech Republic
Ex II 2D Ex tb IIIC	KDB 12 ATEX 0056X	EN 60079-0:2012 EN 60079-31:2014	1453 Experimental Mine "BARBARA", ul. Podleska 72, 43-190 Mikołów, Poland
IEC 60079-29-1	KDB 12 ATEX 0056X	EN 60079-29-1:2007	1453 Experimental Mine "BARBARA", ul. Podleska 72, 43-190 Mikołów, Poland
CE 1026	FTZU 03 ATEX Q 004	EN ISO/IEC 80079-34:2011	1026 Physical-Technical Testing Institute, Pikartska 7, 716 07 Ostrava-Radvanice, Czech Republic

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

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, 01.07.2017

(Name and Signature)
Managing Director
Aleksander Pachole

SmArtGas 3 hardware configuration marking

Device	Trade name	Code									Sensor	Cable gland
		Type	-	M	D	H	E	T	O	X	S	W (Note 1)
Gas detector	SmArtGas 3	PW-044	SG	TS EL ELm VOC DET IR PID	0 LCD FLED FLED.A	HL HH	ALB ALZ SS C	0 T	A D 3W	0 AL AH PK	S-X-X.X	3,2 – 8 mm 6,5 – 11,9 mm 10 – 14 mm 10 – 16 mm[1]

Note 1: For E = ALB, ALZ, C – material: nickel plated brass, for E = SS – 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**)
FLED	with window – bright, multi-colour display	• -40 – 60°C
FLED.A	with window – bright, multi-colour display equipped with an acoustic signaller	• -40 – 60°C

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[2]
HH	sensor cover with sinter, made of stainless steel, warmed	• possibility to realization for M = IR, M = PID

E – enclosure		Limited use
ALB	aluminium, spray epoxy – white	• gas temperature class T6: -40 – 70°C • gas temperature class T5: -40 – 85°C
ALZ	aluminium, spray epoxy – yellow	
C	aluminium, creodur coating – natural aluminium	
SS	stainless steel	

1 Variable clamping range (10 – 12 mm, 12 – 14,5 mm, 14,5 – 16 mm), cable gland material: nickel plated brass.
2 E. g. CO, CH_4. For reactive gases please use Sigma ReAct.

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

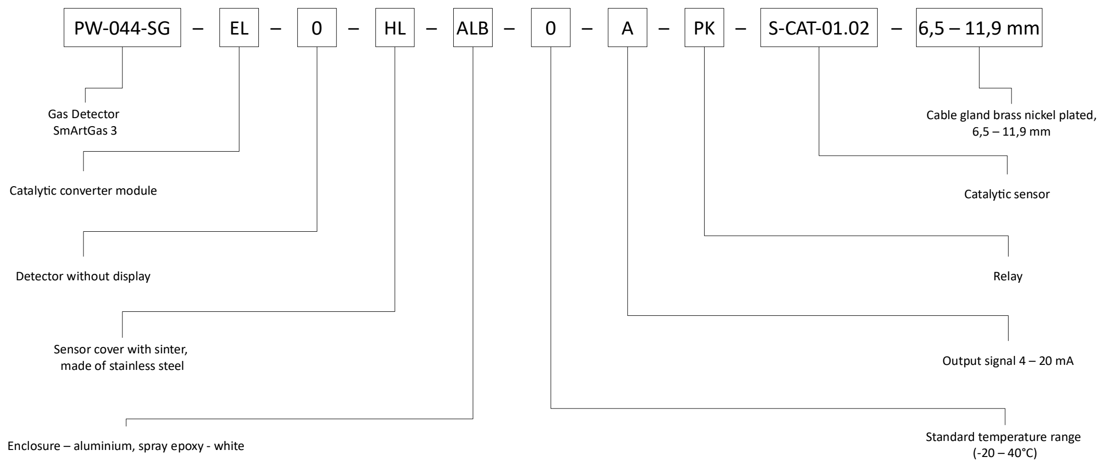
Note 3: The maximum temperature range of the gas detector is limited by sensor, temperature class or display.

O – output signal		Limited use
A	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 O = 3W
AH	4 – 20 mA	• Rob = 500 Ω (only for D = 0) • no possibility to realization for O = 3W
PK	relay	• 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
S-CAT-X.X	catalytic sensor	• see appendix PU-Z-054-ENG
S-HW-X.X	hot-wire sensor	• 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.

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tel.: +48 32 238 87 94
fax: +48 32 234 92 71
e-mail: contact@atestgaz.pl

Sigma SmArt hardware configuration marking

Device	Trade name	Code							Sensor	Cable gland
		Type	-	M	D	H	E	T	S	W (Note 1)
Gas Detector	Sigma SmArt	PW-044	SM	TS EL ELm VOC DET IR PID	0 LCD FLED FLED.A	HL HH	ALB ALZ SS C	0 T	S-X-X.X	3,2 – 8 mm 6,5 – 11,9 mm 10 – 14 mm 10 – 16 mm[1]

Note 1: For E = ALB, ALZ, C – material: nickel plated brass, for E = SS – 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**)
FLED	with window – bright, multi-colour display	• -40 – 60°C
FLED.A	with window – bright, multi-colour display equipped with an acoustic signaller	• -40 – 60°C

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[2]
HH	sensor cover with sinter, made of stainless steel, warmed	• possibility to realization for M = IR, M = PID

E – enclosure		Limited use
ALB	aluminium, spray epoxy – white	• gas temperature class T6: -40 – 70°C • gas temperature class T5: -40 – 85°C
ALZ	aluminium, spray epoxy – yellow	
C	aluminium, creodur coating – natural aluminium	
SS	stainless steel	

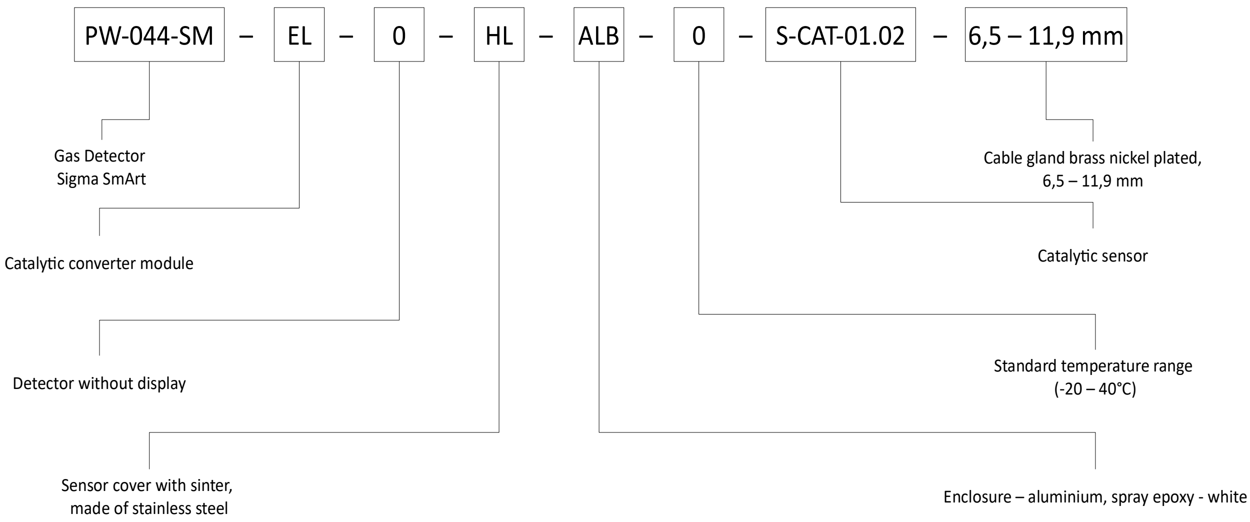
1 Variable clamping range (10 – 12 mm, 12 – 14,5 mm, 14,5 – 16 mm), cable gland material: nickel plated brass.
2 E. g. CO, CH_4. For reactive gases please use Sigma ReAct.

T – temperature range		Limited use
0	standard	• -20 – 40°C
T	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, temperature class or display.

S – type of sensor		Limited use
S-Y[3]-X.X[4]	electrochemical sensor	• see appendix PU-Z-032-ENG
S-CAT-X.X	catalytic sensor	• see appendix PU-Z-054-ENG
S-HW-X.X	hot-wire sensor	• 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.

Parameters of gas detectors with semiconductor sensors DET

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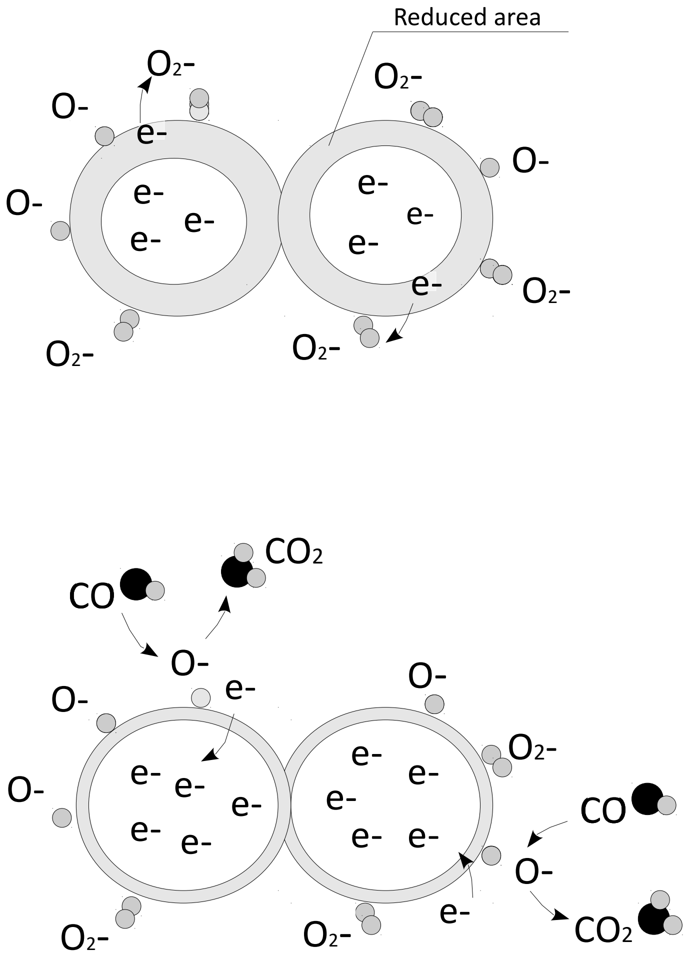
1 Detected substances

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, Ga_2O_3.



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

chemisorption of detected gas

Figure 1: Principle of operation of semiconductor 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 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 NH_3, H_2S, SO_2, 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:

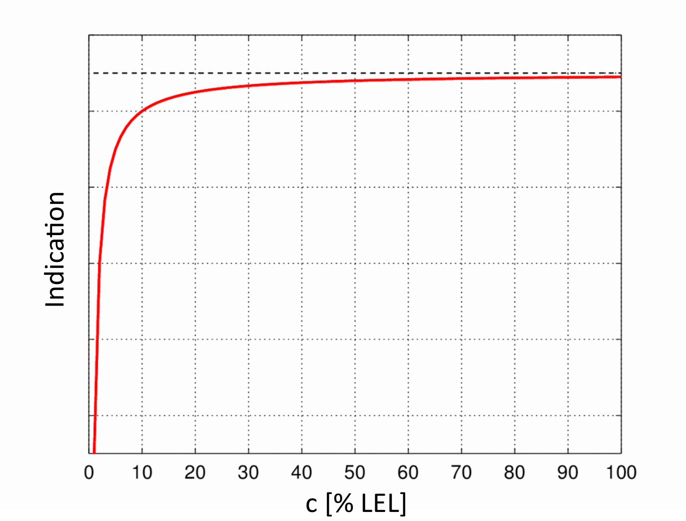


Figure 2: Characteristic of semiconductor sensor

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.

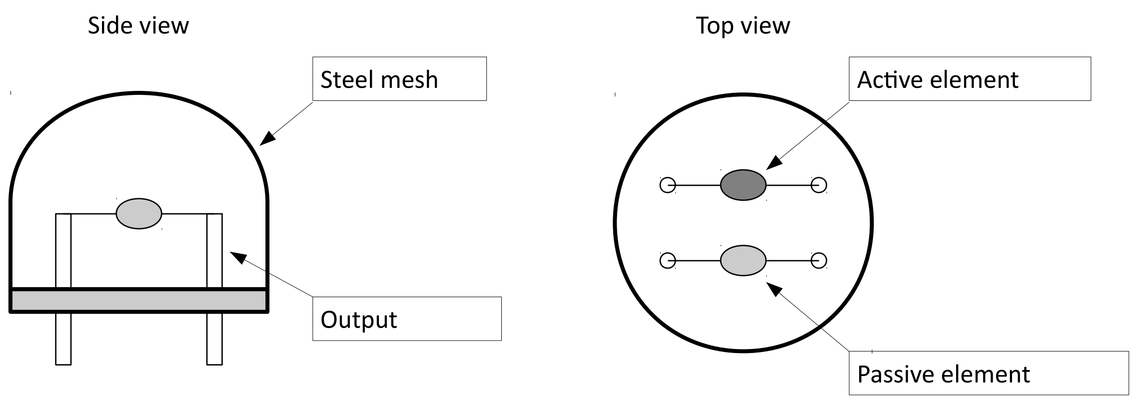

Figure 1: Sample view of catalytic sensor

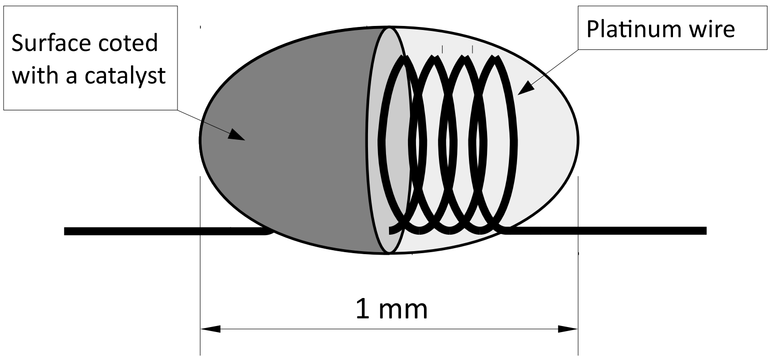

Figure 2: Active element construction

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

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.

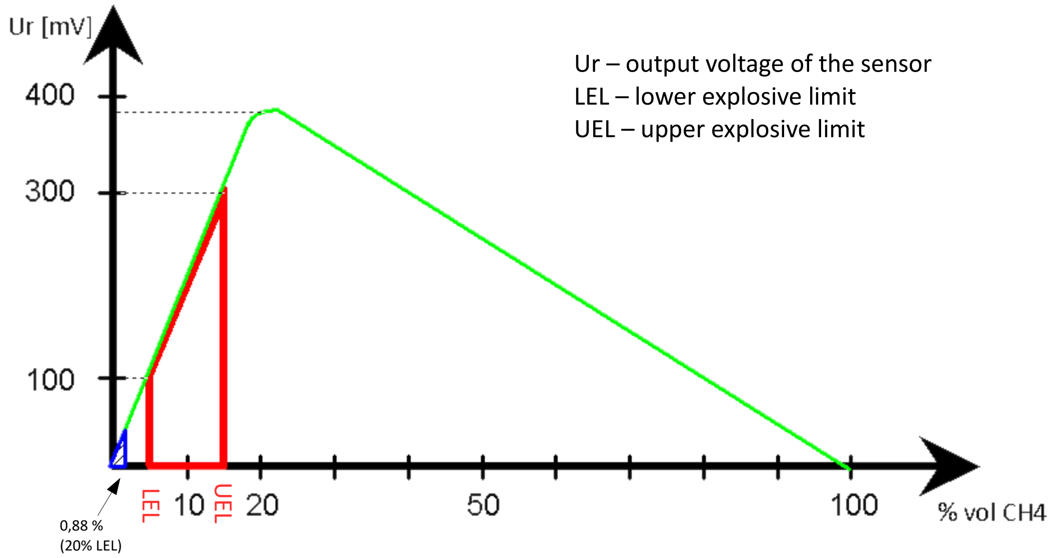

Figure 3: Sample characteristic of catalytic sensor

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 concentration**s** 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,
- olefins – e. g. styrene, propylene, acrylonitrile.

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

Parameters of gas detectors with electrochemical sensor

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1 Detected substances

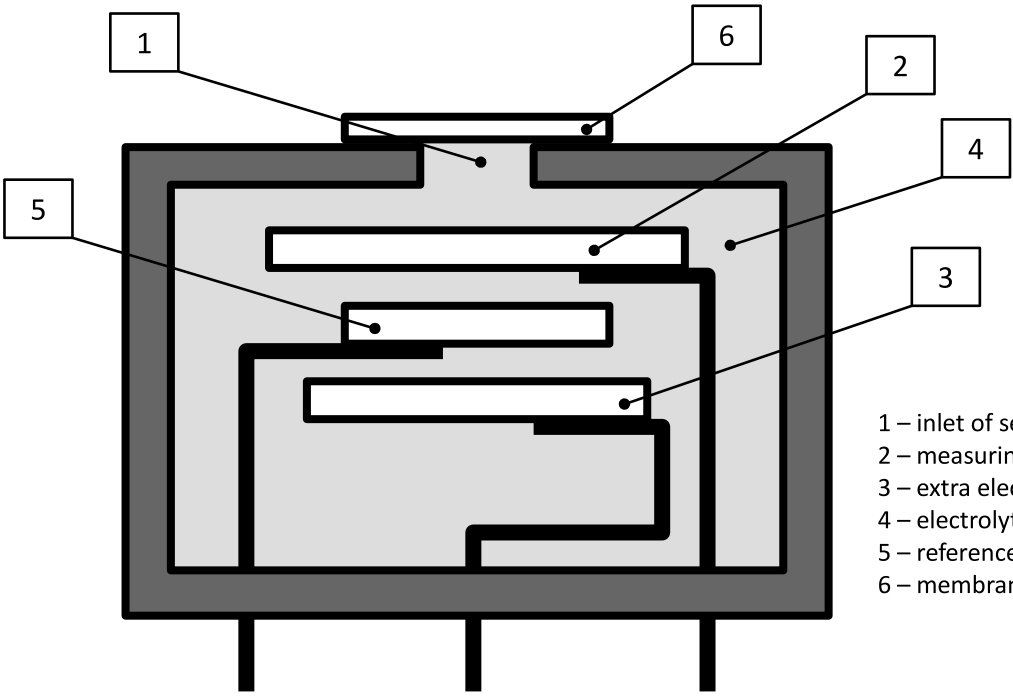
Detectors equipped with electrochemical sensors are used for measuring and detecting the presence of specific substances in gaseous atmospheres in concentrations generally above single "ppm," but in some cases (e.g. oxygen, hydrogen), the concentration may be tens or hundreds of thousands "ppm".
These 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	O2	7782-44-7
Ozon	Trioxygen	O3	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	CO	630-08-0
Chlorine	Chlorine	Cl2	7782-50-5
Chlorine dioxide	Chlorine dioxide	ClO2	10049-04-4
Ethylene oxide, epoxyethane	Oxirane	C2H4O	75-21-8
Formaldehyde	Methanal	HCHO	50-00-0
Hydrazine, diamine, diazane	Hydrazine	N2H4	302-01-2
Hydrogen chloride	Hydrogen chloride	HCl	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	COCl2	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.



1 – inlet of sensor
2 – measuring electrode
3 – extra electrode
4 – electrolyte
5 – reference electrode
6 – membrane

Figure 1: Construction of an electrochemical sensor

Example response to a carbon monoxide sensor:
Sensing electrode: $CO + H_2O \rightarrow CO_2 + 2H^+ + 2e^-$
Counter electrode: $½O_2 + 2H^+ + 2e^- \rightarrow H_2O$
Overall reaction: $CO + ½O_2 \rightarrow CO_2$

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),
- the 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 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,
- 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.

Parameters of gas detectors with photoionization sensors PID

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1 Detected substances

Detectors equipped with photoionization sensors are used for measuring and detecting the present gas substances, whose energy of ionization is lower then 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.

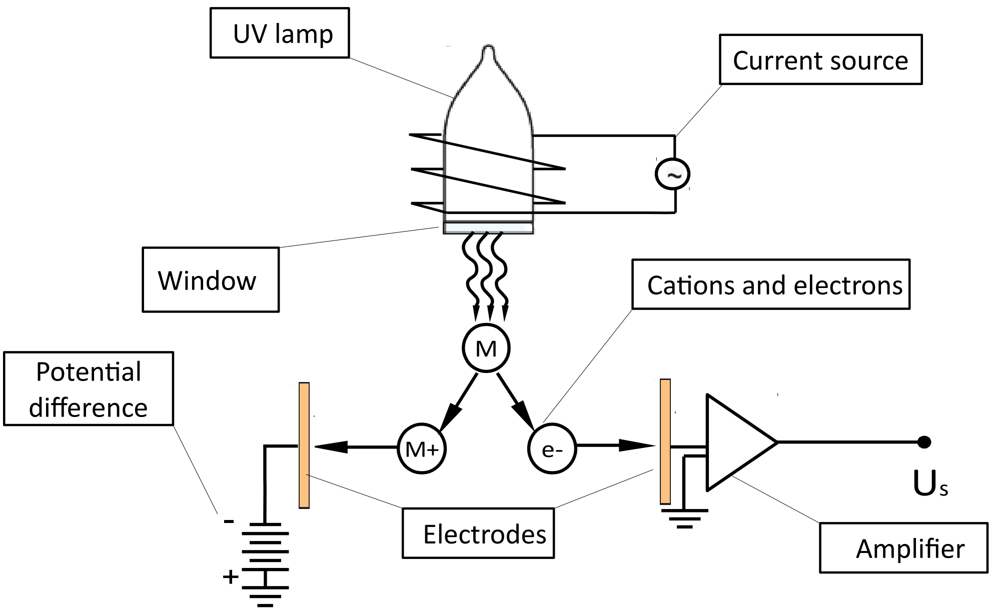

Figure 1: Schematic diagram of the photoionization sensor

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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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.

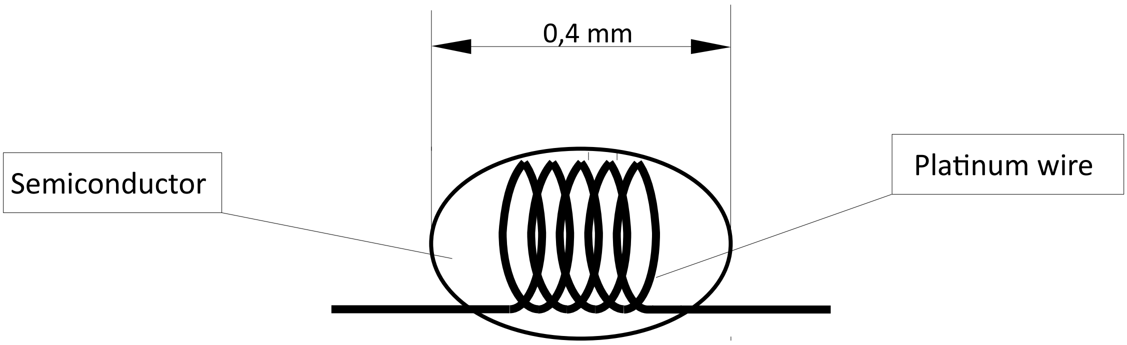

Figure 1: Compensating element construction

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 NH_3, H_2S, SO_2, 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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Appendix: PU-Z-064-ENG R01

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, SF_6).

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.

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/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.

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 NH_3, H_2S, SO_2, 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).

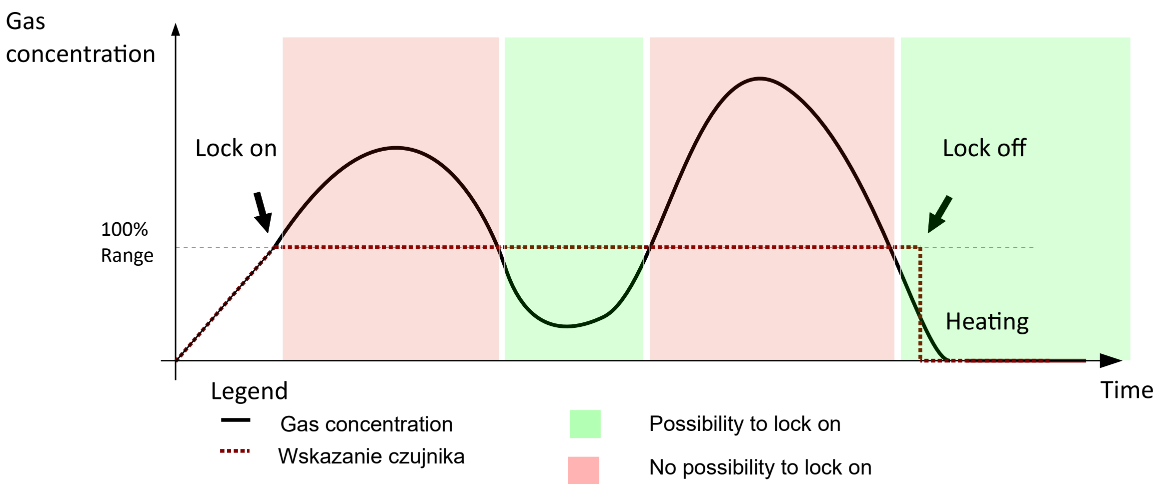

Figure 1: Operation of lock on /off detector

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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 diameter [mm]	Maximum cable length [m]
Outdoor installations	Indoor installations		
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.

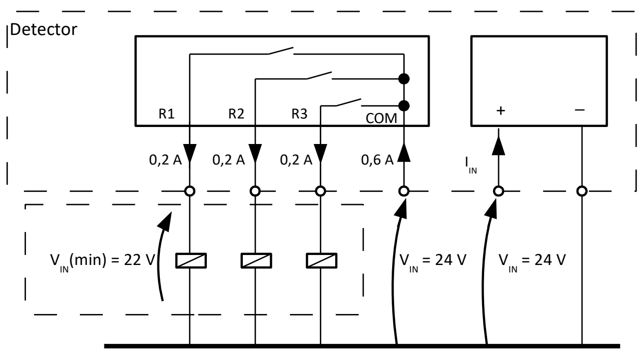
2 Connection cable

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 diameter [mm]	Maximum cable length [m]
Outdoor installations	Indoor installations		
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



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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

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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 cables[1] for connecting gas detectors:

An example of a cable symbol		Approximate outer diameter [mm]
Outdoor installations	Indoor installations	
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).

1 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 mm^2: R(2x800 m) = 36 / 1000 * 1600 = 57.6 Ω > 54 Ω
  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 mm^2: R(2x800 m) = 18 / 1000 * 1600 = 28.8 Ω < 54 Ω
  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.

Shielded cables applied for connecting detectors – preparation and installation

The cable shall be prepared in accordance with the following guidelines (see also 1):

- the cable external sheath shall be removed at the applicable length (see 1),
- the cable shield shall be cut right by the end of the external sheath,
- the cable shield shall be protected with isolation,
- at the ends of the cables, isolated clamp sleeve shall be placed,
- he conductive part of the clamp sleeve shall have applicable length (see 1).

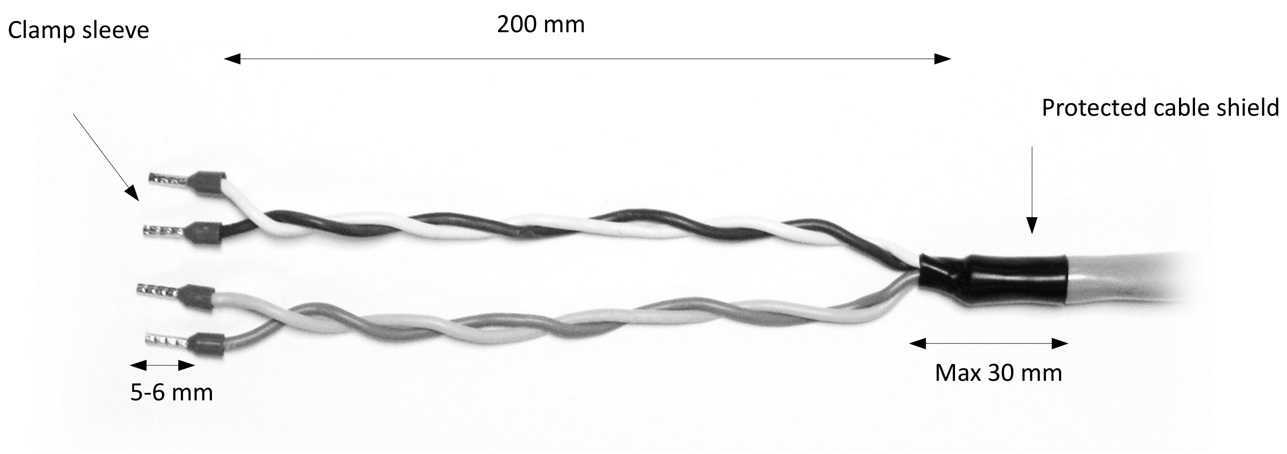


Figure 1: Cable preparation

For the systems with RS-485 interface, it is necessary to make sure that A and B transmission signals as well as + and – power supply were led with the use of the cables which belong to one pair.

The cable shall be placed in the detector as shown on figure 2. It is necessary to make sure that the shield protection is not located in the rubber element of the cable entry and that the smallest part of the cable external sheath was located inside the detector.

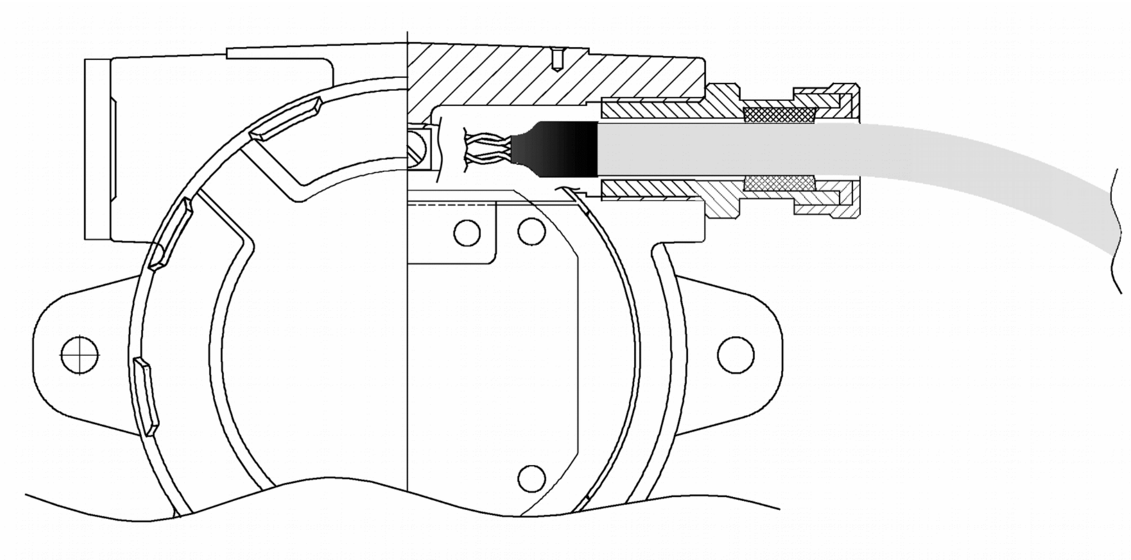


Figure 2: Placing cables in the detector

When laying the cable inside the detector enclosure, it must be remembered that:

- cables should be ordered,
- connecting cables should be kept as far away from the detector electronics as possible and routed as directly as possible to the crimp connection,
- it is necessary to minimize the amount of unnecessary conductor on the detector electronics. It is unacceptable to leave a reserve inside the detector.

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
● (red)	Optical indicator on
⊘ (red)	Optical indicator flashing
○	Optical indicator off
⊙	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
● - yellow	Detector's critical failure	-
○ - white	Test, calibration	-

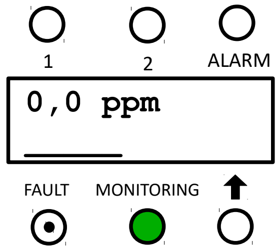
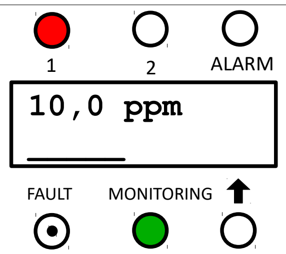
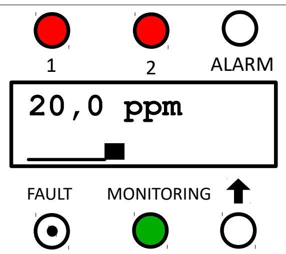
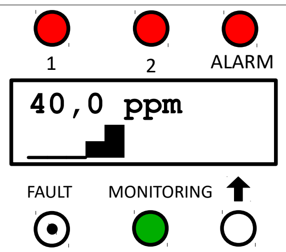
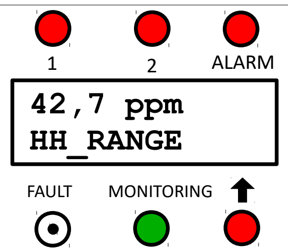
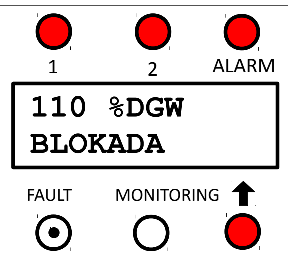
3 Gas detector with LCD display (D=LCD)

3.1 Description of detector state indicators

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

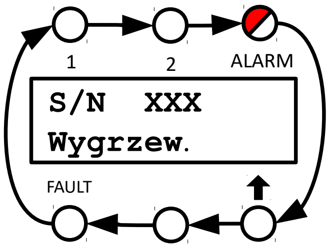
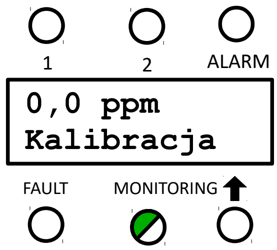
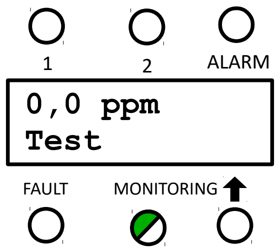
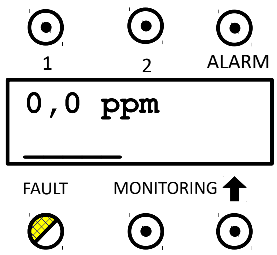
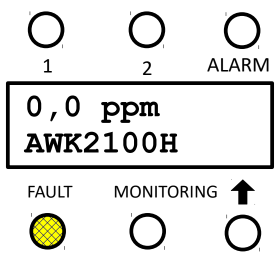
The display has light-sensitive area, which ensures appropriate backlit of the display during operation in an unlit room.

3.2 Detector's state signalling – gas alarms

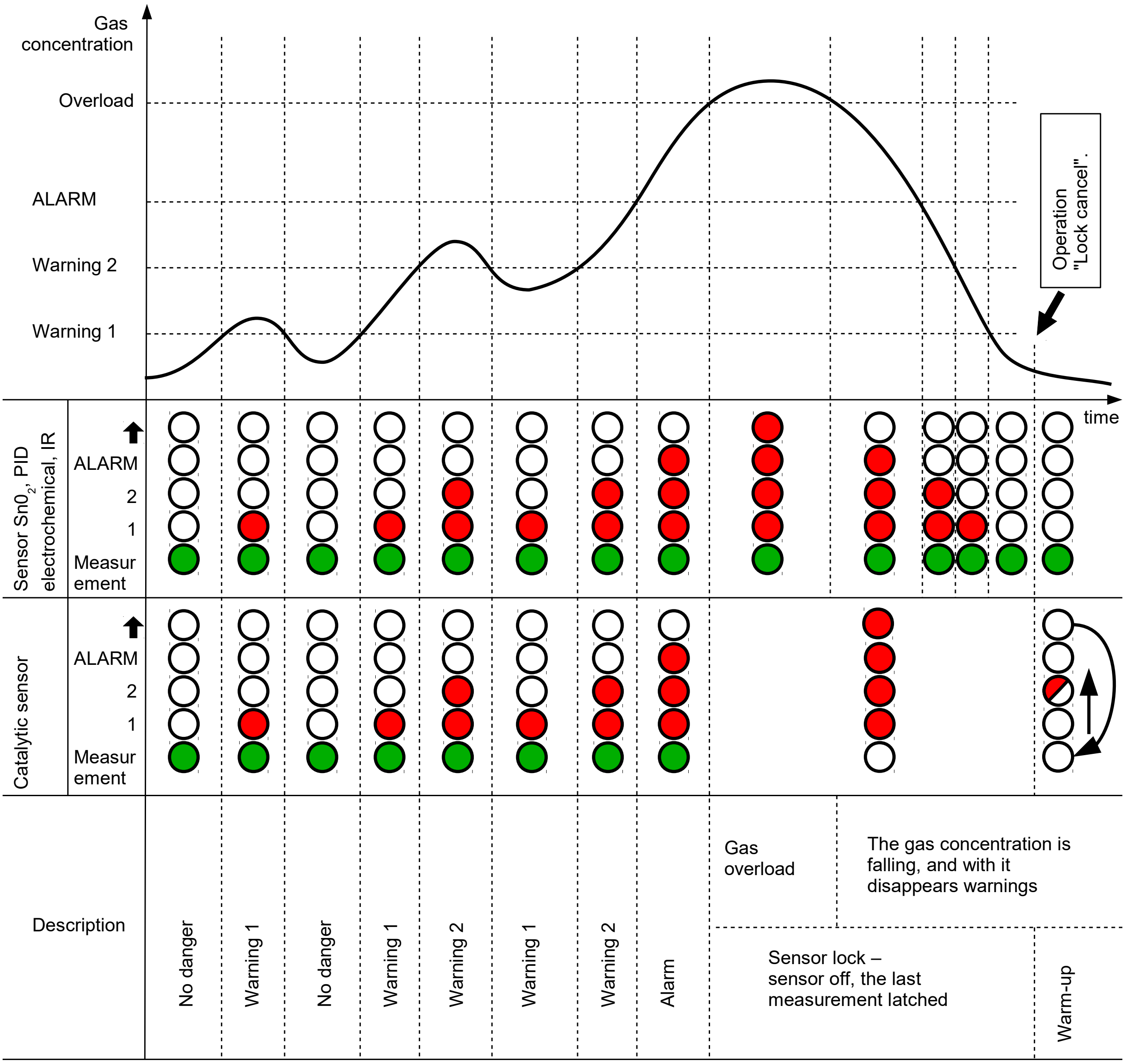
Situation	Description	Indicators/display[1]
No danger	The detector works properly, measures the concentration, which is indicated by continuously lit MONITORING indicator.	
Warning 1	The gas concentration exceeds the first warning threshold. Indicator 1 in the panel is continuously lit. The detector performs measurement, which is indicated by continuously lit MONITORING indicator	
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	
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	
Overload	The gas concentration exceeds the overload value. Indicators 1, 2 and ALARM and 🠉 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.	
Lock[2]	The gas concentration exceeds the overload value. Indicators 1, 2 and ALARM and 🠉 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 Display description contains sample content.
2 The state occurs only in case of detectors with a catalytic sensor. The lock mechanism is active.

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 Wygrzew (Heating).	
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 Kalibracja (Calibration).	
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 (_⊓_⊓_____). The display shows Test message.	
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.	
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.	

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



3.5 Failure codes

Message	Description
AWK<failure code>	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>	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	Type
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
11..15	-	Inessential data, can take any value

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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. B0 A0).
The detector are classified on the stage of offer.

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

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Category	Description	Terms of facility calibration
A0	Cylinder gases, stable environment	No precipitations, and no strong winds, and temperature over **– 10°C**[1]. 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°C**[1], 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).
A3	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
B0	Safe substances	concentration of flammable components **< 60% LEL**, and concentration of toxic components ≤ **NDSCh**[2], and oxygen concentration **< 25% vol**, and tank **< 3 dm³** (water capacity) and **p ≤ 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 ≤ **NDSCh**[2], 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.
B2	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.
B3	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

1 Is allowed to perform calibrations at lower temperatures, if they meet the conditions of operation of the detector, e.g. ammonia refrigeration units.
2 In the absence of determined NDSCh it is necessary to adopt 2 x NDS as a criterion.

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