



User Manual

Sensors used in gas detectors produced by Atest Gaz



We design, manufacture, implement and support:
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1 Electrochemical sensors

1.1 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.

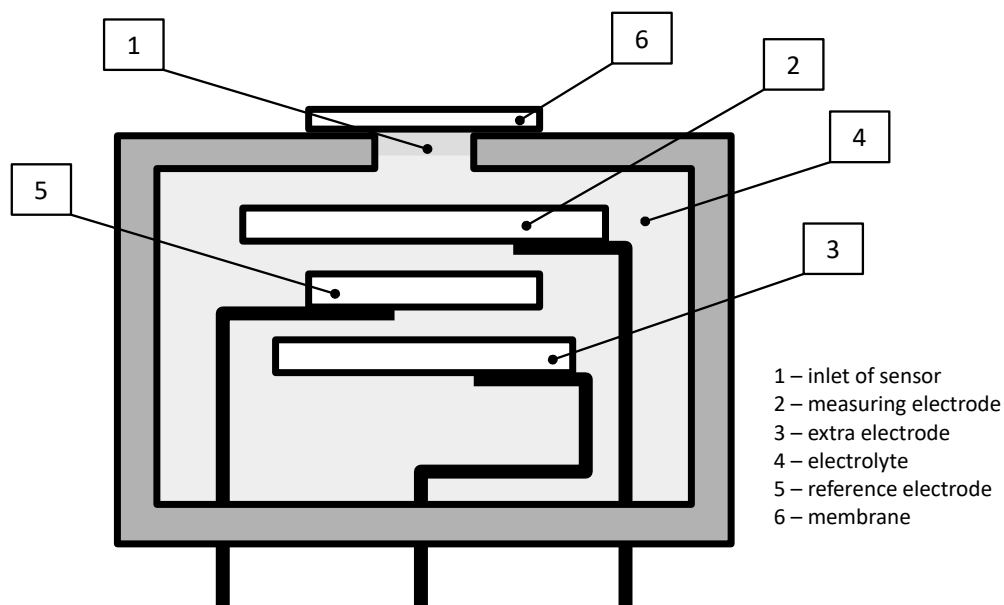
Name of the substance	IUPAC name	Molecular formula	CAS
Oxygen	Oxygen	O ₂	7782-44-7
Ozon	Trioxxygen	O ₃	10028-15-6
Hydrogen	Hydrgen	H ₂	1333-74-0
Ammonia	Azane	NH ₃	7664-41-7
Arsine	Arsenic trihydride, Arsane	AsH ₃	7784-42-1
Carbon monoxide	Carbon monoxide	CO	630-08-0
Chlorine	Chlorine	Cl ₂	7782-50-5
Chlorine dioxide	Chlorine dioxide	ClO ₂	10049-04-4
Ethylene oxide, epoxyethane	Oxirane	C ₂ H ₄ O	75-21-8
Formaldehyde	Methanal	HCHO	50-00-0
Hydrazine, diamine, diazane	Hydrazine	N ₂ H ₄	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	H ₂ S	7783-06-4
Nitric oxide	Oxidonitrogen	NO	10102-43-9
Nitrogen dioxide	Nitrogen dioxide	NO ₂	10102-44-0
Phosgene	Carbonyl dichloride	COCl ₂	75-44-5
Silane	Silane	SiH ₄	7803-62-5
Sulphur dioxide	Sulphur dioxide	SO ₂	7446-09-5
Ethylene	Ethene	C ₂ H ₄	74-85-1
Tetrahydrotiofene (THT)	Thiolane	C ₄ H ₈ S	110-01-0

Table 1: Substances detected by the electrochemical sensors

1.2 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: $\text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + 2\text{H}^+ + 2\text{e}^-$

Counter electrode: $\frac{1}{2}\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{O}$

Overall reaction: $\text{CO} + \frac{1}{2}\text{O}_2 \rightarrow \text{CO}_2$

1.3 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.

1.3.1 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]	Ingredient	C [%vol]	C [ppm]
Nitrogen	78.084	780 840	Helium	0.00052	5.24
oxygen	20.946	209 460	Methane	0.00017	1.70
Argon	0.934	9340	Krypton	0.00011	1.14
Carbon dioxide	0.0360	360	Hydrogen	0.00005	0.50
Neon	0.00181	18.18	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.




1.3.1.1 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.

1.3.1.2 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.

1.3.1.3 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.





1.3.2 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.

1.3.3 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.

1.3.4 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.






1.3.5 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.

1.4 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.





2 Photoionization sensors PID

2.1 Detected substances

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

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

-  Aliphatic hydrocarbons – e. g. pentane, octane, hexane,
-  Aromatic hydrocarbons – e. g. toluene, xylene, benzene,

-  alcohols – e.g. ethanol, propanol,
-  aldehydes, ketones, esters,
-  amines, sulphides,
-  others, including: aviation fuels, petrol, and some inorganic compounds.

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

2.2 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.

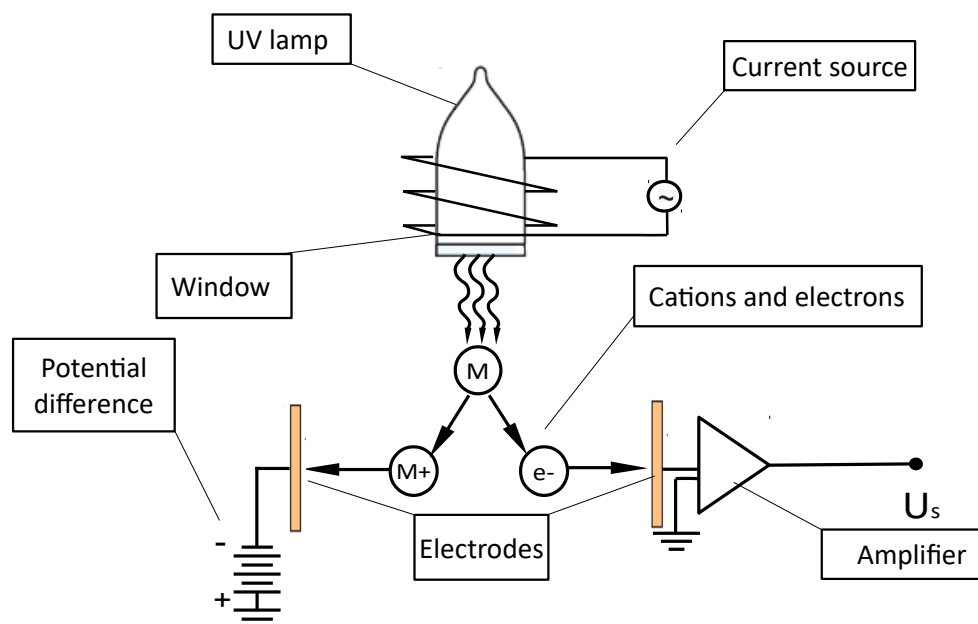





Figure 2: Schematic diagram of the photoionization sensor

2.3 Impact of environmental conditions

2.3.1 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.

2.3.2 Influence of temperature

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

2.3.3 Influence of moisture

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

2.3.4 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.

2.3.5 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.

2.4 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.

3 Hot-wire sensors

3.1 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.

3.2 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.

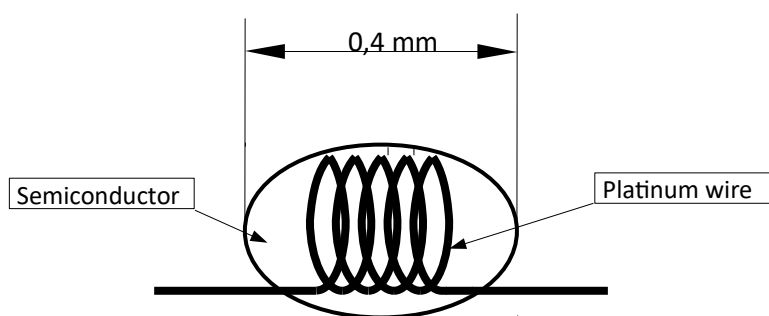


Figure 3: Compensating element construction

3.3 Impact of environmental conditions

3.3.1 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.

3.3.1.1 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.

3.3.1.2 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.

3.3.2 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.

3.3.3 Influence of pressure

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

3.3.4 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.

3.3.5 Influence of vibrations, impacts

Strong vibrations and impacts may cause damage of the sensor.

3.4 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.

4 IR sensors

4.1 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.

4.2 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.



4.3 Impact of environmental conditions

4.3.1 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.

4.3.1.1 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. CO₂ in the CH₄ detector).

4.3.1.2 Effect of oxygen concentration value

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

4.3.2 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.

4.3.3 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.

4.3.4 Influence of moisture

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

4.3.5 Influence of vibrations, impacts

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

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

4.3.6 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.

4.4 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.

5 Catalytic sensors

5.1 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.

5.2 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.

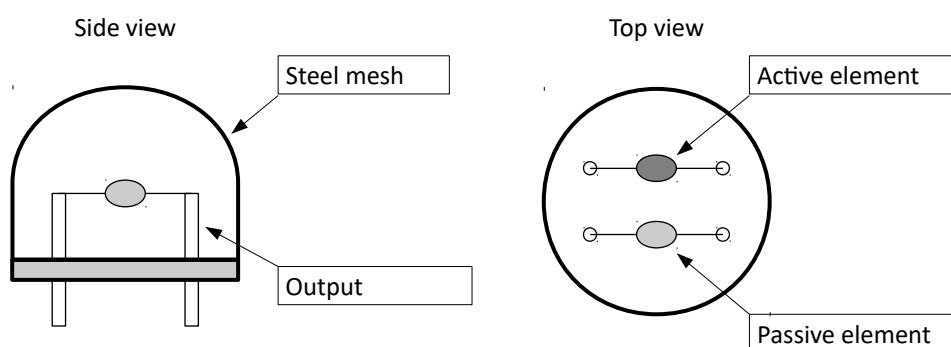


Figure 4: Sample view of catalytic sensor

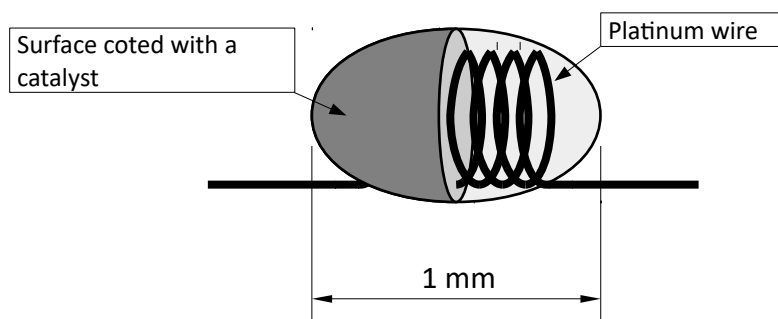


Figure 5: Active element construction

5.2.1 Impact of environmental conditions

5.2.1.1 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.

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%.

5.2.1.2 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 5.2.1.3.

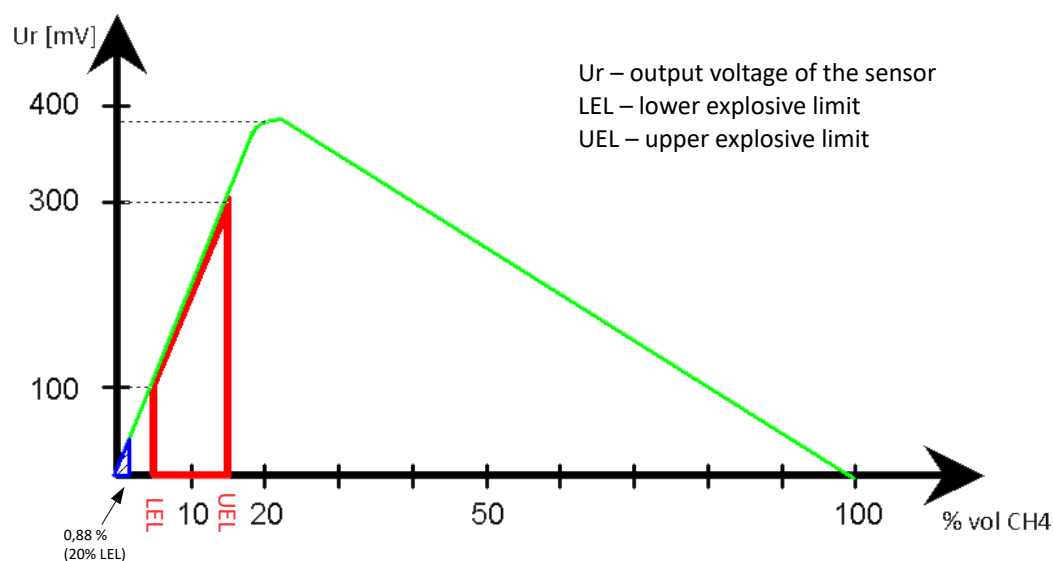


Figure 6: Sample characteristic of catalytic sensor

5.2.1.3 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.

5.2.2 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.

5.2.3 Influence of pressure



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

5.2.4 Influence of moisture

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



5.2.5 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/s².



5.2.6 Influence of physicochemical phenomena

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

5.3 Factors shortening the lifetime of the sensor

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.

6 Semiconductor sensors DET

6.1 Detected substances

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

6.2 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 7). 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 7).

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 .

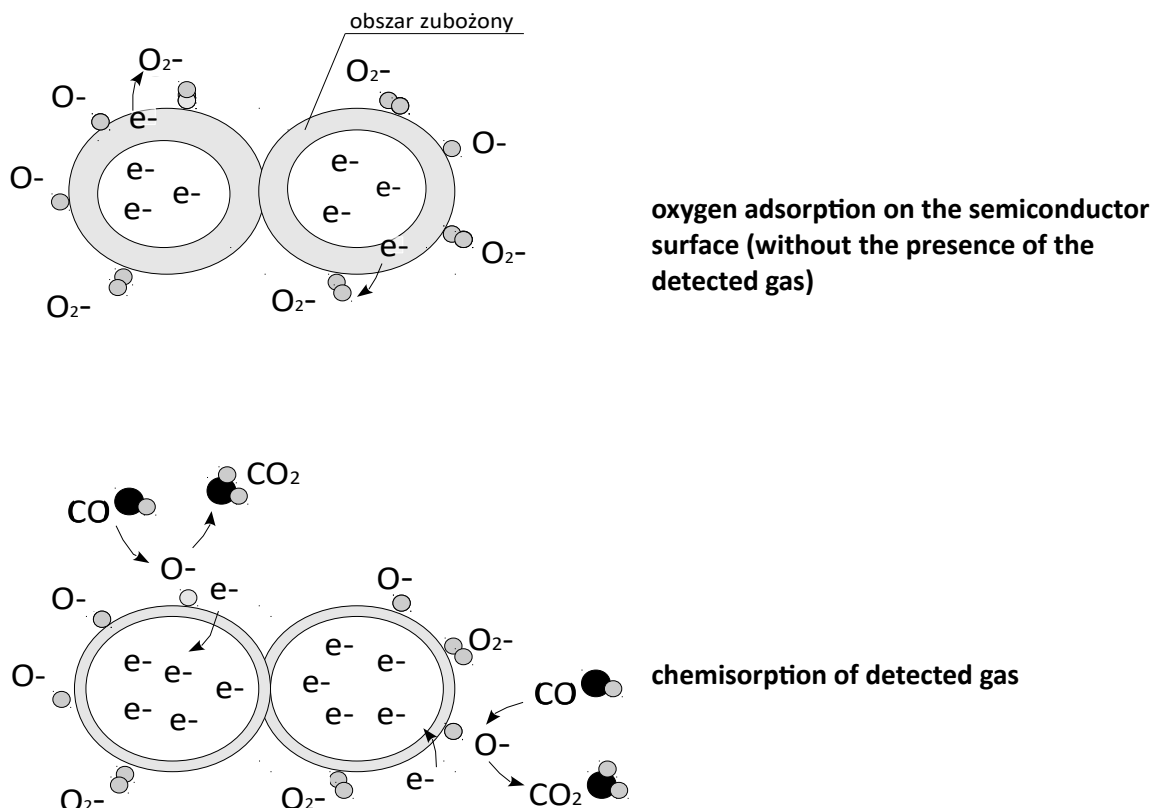







Figure 7: Principle of operation of semiconductor sensor

6.3 Impact of environmental conditions

6.3.1 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.

6.3.1.1 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.

6.3.1.2 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%.

6.3.2 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.

6.3.3 Influence of pressure

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

6.3.4 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.


6.3.5 Influence of vibrations, impacts

Vibrations and impacts may cause damage of the sensor.

6.4 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:

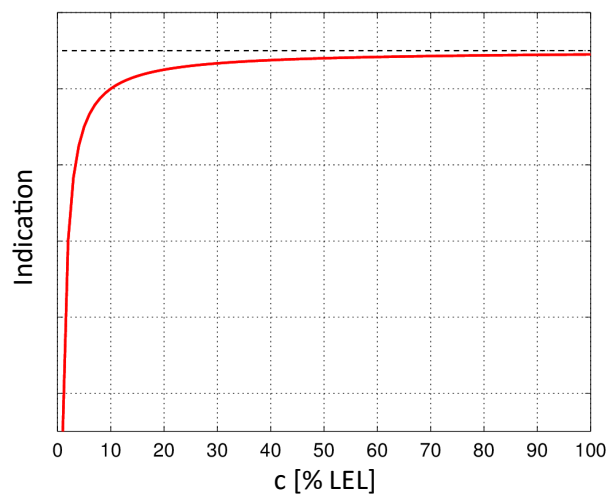


Figure 8: Characteristic of semiconductor sensor

