
1 ATMOSPHERE PARAMETERS CONTROL IN THE UNDERGROUND COAL MINES

1.1 Introduction

One of the basic conditions of safe work in the underground coal mines is preservation of suitable physical and chemical parameters of the mine atmosphere [1]. Composition of mine atmosphere, that is air present in mine headings, differs from composition of an atmospheric air. It is caused by emission of gases contained in the rock mass, consumption of oxygen and emission of carbon dioxide during breathing, emission of gases during mining, transport and oxidation of organic substances processes etc.

Oxygen (O_2) is an indispensable component of air during breathing process. The regulations in force for Polish mining industry requires that oxygen content in mine atmosphere should not be lower than 19%. When mentioned content is lower people feel somnolence, have rapid heartbeat, disturbances of consciousness while when oxygen content is below 12% - it can be fatal.

Nitrogen (N_2) is a colourless, odourless, tasteless gas, neutral for breathing processes, but increasing of its content leads to decrease of oxygen content in the air. Nitrogen is emitted to the mine atmosphere during decomposition of organic matter, during blasting works, is present in natural gas in bed and can flow out from dammed fire areas where nitrogen is forced in order to accelerate fire extinguishing process.

Carbon dioxide (CO_2) is a colourless, odourless gas. In reaction with water it forms acid and therefore its presence can be sensed by taste. Is a suffocating gas. Elevated contents of this gas in the air causes headaches and dyspnoea, loss of consciousness can occur in case of content over 10% and in case when it's over 25% - it is lethal. Carbon dioxide is a component of bed gas, is formed during breathing, as a result of fires or oxidation of organic matter, is emitted during blasting works and operation of combustion engines.

Carbon monoxide (CO) is a gas without colour, without odour and without taste. It is a flammable gas and within the concentrations from 12.5% to 75% is explosive. It belongs to very toxic gases. Carbon monoxide is formed in underground mines mainly as a result of fires and low-temperature coal oxidation, during explosion of coal dust or methane as well as during operation of combustion engines.

Nitrogen oxides (NO , NO_2 , N_2O_4 , N_2O_5) have brown colour and strong odour. They belong to very toxic gases. Concentration in the air equal to 0.025% is lethal for people. Nitrogen oxides are formed during blasting works and during operation of combustion engines.

Sulphur dioxide (SO_2) is a colourless gas, with strong taste and smell. It is very toxic and at 0.05% concentration is dangerous for people even after short exposure. Sulphur oxide is formed mainly during blasting works and operation of combustion engines.

Hydrogen sulfide (H_2S) is a colourless gas with characteristic smell of rotten eggs. It is a flammable gas and within the concentration in air from 4.3% to 46% is explosive. Hydrogen sulfide is very toxic similarly as sulphur dioxide. The source of hydrogen sulfide are digestion processes, decomposition of pyrite by the action of water, underground fires and emissions from slots and underground water reservoirs.

Hydrogen (H_2) is a colourless gas, without smell, without taste, soluble in water. It is a flammable gas and within the concentrations from 4% to 75% is explosive. Hydrogen is present in reservoir gas and is formed during charging of the accumulators as well as during fires.

Methane (CH_4) is a colourless gas, without smell and without taste. It is a flammable gas and within the concentrations from 5% to 15.5% is explosive. The most intensive explosion takes place at the concentration of methane in the air equal to 9.5%. Methane ignition temperature, depending on physical parameters of the mixture, is equal from 6500 to 7500. Methane is a reservoir gas formed during coalification of plants. It is also formed during fires as a result of dry distillation of the carbonaceous matter. Methane can accumulate under the heading's roof in weak ventilation conditions forming explosive or flammable layer. In order to prevent occurrence of this phenomenon the proper air velocity in the headings should be maintained.

In tab. 1.1 designation MAC (Maximum Allowable Concentration; in Polish: NDS) is a concentration, which action on employee during 8-hour work period, by period of her/his professional activity should not cause negative changes in her/his health and health of the future generations, while STEL (Short Term Exposure Limit; in Polish - NDSCh] is a value of mean concentration of specified, toxic chemical compound, which should not cause negative changes in health of the employee, if it is present in the work environment for not longer than 15 minutes and not often than 2 times in work shift, in the interval of time not shorter than 1 hour.

Tab. 1.1 Allowable concentrations of noxious gases in mine atmosphere

Type of gas	MAC mg/m ³ (by volume %)	STEL mg/m ³ (by volume %)
Carbon dioxide	- (1.0)	- (1.0)
Carbon monoxide	30 (0.0026)	180 (0.015)
Nitrogen oxide	5 (0.00026)	10 (0.00052)
Sulphur dioxide	20 (0.00075)	50 (0.0019)
Hydrogen sulfide	10 (0.0007)	20 (0.0014)

Concentration of the given gases in mine atmosphere are strictly connected with physical parameters of the mine atmosphere and especially with volume flow of the air in the workings. Air volume flow is determined on the basis of velocity of air flow measurements and on the basis of cross-section of the working.

The other important physical parameters, especially when taking into account so-called thermal comfort of the work, are temperature and humidity of the air.

Chemical composition of the mine atmosphere is determined in laboratory using manual measuring instruments or using automatic gasometer instruments.

Physical parameters are measured manually or using automatic remote measuring (telemetric) systems. Airflow in mine workings can be controlled thanks to suitably selected system of ventilation stoppings. In order to maintain proper physical parameters of the mine atmosphere it is required to check condition of ventilation stoppings. Mentioned inspection is performed visually, by manual measurements or automatic measurements.

Remote measurement (telemetrical) systems have essential meaning in maintaining of atmospheric safety conditions in the mine. However it should be remembered that detectors of these systems are operated almost exclusively in stationary mode so they are measuring proper parameters, at least for some period, in the accurately specified location. That is why also manual measurements are indispensable.

1.2 Construction of the telemetrical measuring systems on the example of the KSP system

The KSP safety system is manufactured by Przedsiębiorstwo Kompletacji i Montażu Systemów Automatyki CARBOAUTOMATYKA S.A. [2]. The KSP Safety System consists of:

- Remote measurements (telemetrical) systems (units) KSP-2C or KSP-3,
- Measuring devices (e.g. Methane detectors, CO-meters etc.)
- Supply-transmission lines.

This system cooperates with other safety systems, such as alarm-broadcasting system Hetman, SAT, master systems ZEFIR, SW μ P, SD2000, SOLARIS.

Technical solutions and possible configurations of the KSP safety system corresponds to the regulations included in the standards, regulations and laws in force for such systems.

Remote measurements (telemetrical) systems KSP-2C or KSP-3, which are part of the safety system, are used to control atmosphere in locations specified by person responsible for atmospheric safety conditions in the mines. The newest product of CARBOAUTOMATYKA S.A. is a remote measurement (telemetrical) unit KSP-3 (fig. 1.1).

The KSP-3 unit is responsible for activation, processing and back-up of signals from terminal devices operating in the headings. A maximum number of 40 detectors and/or other devices can be connected to the KSP-2C unit, while for KSP-3 unit this number is equal to 320 detectors and/or other devices (e.g. underground exchanges of bi-state signals, current transducers, disconnecting devices). There can be up to 10 pieces in total operating in one system based on KSP-2C units, so one system can have up to 400 measuring points. In case of system based on KSP-3 units there is no such limitations.

Connected detectors, depending on their capabilities (construction limitations) can communicate with the unit (be polled) in the following time periods:

- 0.3 second (in case of use of KSP-3 unit),
- 4 seconds,
- 8 seconds,
- 48 seconds.

Units are able to perform so-called “quick disconnections”, so they can send alarm impulses from the surface to any number of programmed disconnecting devices. This make

it suitable to switch off electric energy supply to the earlier planned number of electric devices. This function is for example used to switch off electric energy when allowable methane concentration is exceeded in place of methane detector's installation or when the air flow velocity decreases in place of installation of stationary anemometer.

which are defined individually for each detector using computer's keyboard:

- Warning alarm AO, which depending on status, signals visually and acoustic on the monitor's screen about its exceeding or additionally will send independent tripping out signal to the measuring line;
- Primary alarm AG, which exceeding is signalled visually and acoustic results in sending of alarm impulses to the earlier programmed tripping out devices located in underground of the mine;
- Thanks to use of increments and drops alarm APS, the unit informs a dispatcher beforehand about possibility of exceeding of an allowable concentration of e.g. carbon monoxide or too low oxygen level in the area of installed detector.

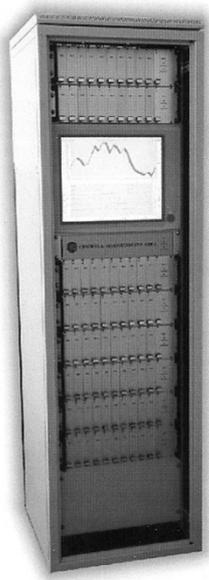


Fig. 1.1 KSP-3 unit

Control of unit's operation and analysis of measurements results can be performed using suitable unit's equipment or dispatcher computer. Possibility to connect it to the computer is especially important when several KSP units are connected with each other.

Units of the KSP system have three alarm thresholds

There is a possibility to send alarm impulses between measuring lines of the units when the KSP system's network is constructed of at least two units' racks. This function is realized by connection of the units by RS-485 bus. Such feature is especially important when detectors of one ventilation area are connected to two units.

KSP units can cooperate with many types of terminal devices. These detectors can have different construction and can be manufactured by different companies. Selected detectors manufactured by CARBOAUTOMATYKA S.A. as well as stationary anemometer manufactured by PAN Kraków are presented below.

Methane detector SC-CH₄/* (fig. 1.2) is manufactured in three versions: n, s and W (asterisk in the name is replaced by the version's designation).

This detector is intended for continuous measurement of methane concentration within the range from 0% to 100% in the workings in any zone of methane hazard and coal dust explosion hazard. The detector operates in stationary instrument mode. Methane detector is equipped with function of disconnecting device. Alarm thresholds can be set to any value within the range 0%÷2% CH₄ for n and s version and/or within the range 30%÷80% CH₄ for

version SC-CH₄/W. Exceeding of the above mentioned threshold (for version n or s) or drop below 30% in version W of the methane detector results in activation of alarm (pulsation of the red diode) and sending of proper information to the unit or device switching off electric energy supply of the appropriate machine or device.

Concentration measurement is performed by a pellistor sensor within the ranges from 0%÷5% CH₄ and 5%÷100% CH₄ for version n and s or 0%÷100% CH₄ for version W. Measuring error for version n and s is equal to: 0.1% CH₄ within measuring range 0%÷2.5% CH₄, 0.3% CH₄ within range 2.5%÷5% CH₄ and 3% within range 5%÷100% CH₄.

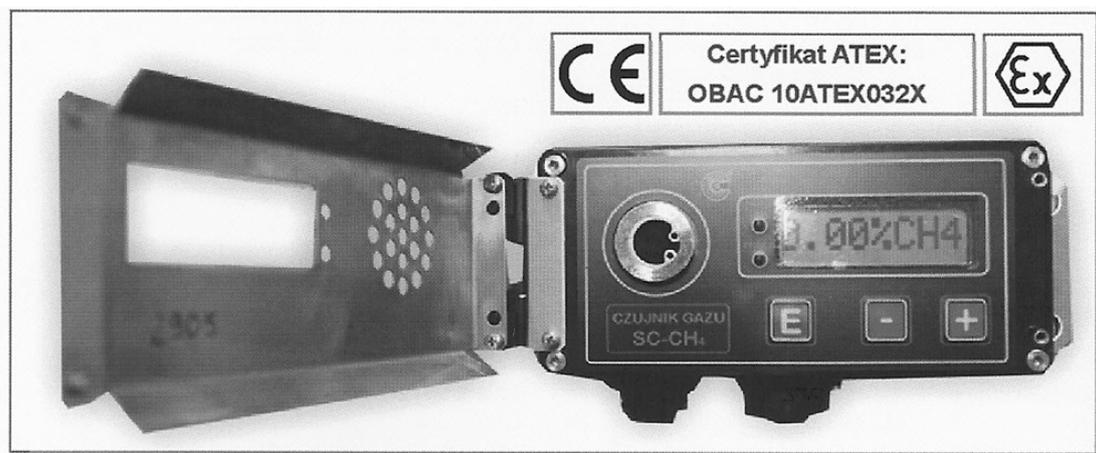


Fig. 1.2 Methane detector SC-CH₄/*

Measuring error for W version is equal to: 3% CH₄ within range 0%÷60% CH₄ and 5% CH₄ within range 60%÷100% CH₄.

Response time T₉₀ is not longer than 3.5 sec. Actuation time of alarms is below 1 second.

Carbon monoxide sensor SC-CO/* (fig. 1.3) is intended for continuous measurement of carbon monoxide concentration within the range 0÷200 ppm (version n) or 0÷1000 ppm (version s).



Fig. 1.3 Carbon monoxide detector

The detector operates in stationary mode. It is equipped with two disconnecting thresholds, enabling to control external devices. Thresholds can have any value within the range 0÷26 ppm. CO concentration measurement is made on the electrochemical basis.

Measurement error for version n is equal to ± 3 ppm CO for range 0÷100 ppm CO, ± 5 ppm CO for range 100÷200 ppm CO and for version s ± 25 ppm CO for range 0÷1000 ppm CO.

Response time T90 is not longer than 20 sec.

Carbon dioxide sensor SC-CO₂/* (fig. 1.4) is a device intended for continuous measurement of carbon dioxide concentration within the range 0%÷5% CO₂. The detector operates in stationary mode.



Fig. 1.4 Carbon dioxide detector

Detector is equipped with two disconnecting thresholds, enabling to control external devices. These thresholds can be set to any values from the range 0%÷1% CO₂. Exceeding of these thresholds calls an alarm and sets proper state of detector's input or output.

Detector is manufactured in two versions: n and s.

Measurement error is equal to 0.1% CO₂ within measurement range 0%÷2.5% CO₂ and 0.3% CO₂ within the range 2.5%÷5% CO₂. Measurement is carried out on the basis of infrared radiation adsorption. Response time T90 is not longer than 30 sec.



Fig. 1.5 Toxic gases detector

Carbon dioxide, methane and carbon monoxide are continuously present in the mine atmosphere. Naturally concentration of these gases varies in time and only in some periods can be hazardous. Whereas other gases damaging to health are rarely present, some of them only during fires, but also can be a reason of a breakdown.

The below presented detectors of toxic gases (fig. 1.5), with these described above), ensures the necessity of determination of MAC and SLET (in Polish - NDS and NDSCh) for gases included in the tab. 1.1, expanding measuring capabilities to other gases.

CARBOAUTOMATYKA S.A. offers detectors for the following toxic gases (except the already described carbon monoxide detector):

- Hydrogen sulfide (H₂S) - designation of the sensor SC-H₂S/*,
- Ammonia (NH₃) - designation of the sensor SC-NH₃/*,
- Nitrogen oxide (NO) - SC-NO/*,
- Nitrogen dioxide (NO₂) - designation of the sensor SC-NO₂/*,
- Chlorine (Cl₂) - designation of the sensor SC-Cl₂/*,
- Sulphur dioxide (SO₂) - designation of the sensor SC-SO₂/*,
- Hydrogen cyanide (HCN) - designation of the sensor SC-HCN/*.
- These sensors can be manufactured in the n version, or on the customer's demand in version s (special)
- Measuring ranges for the following detectors are presented below:
 - Detector SC-H₂S/n - 0÷20 ppm H₂S,
 - Detector SC-NH₃/n - 0÷100 ppm NH₃,
 - Detector SC-NO/n - 0÷50 ppm NO,
 - Detector SC-NO₂/n - 0÷10 ppm NO₂,
 - Detector SC-Cl₂/n - 0÷10 ppm Cl₂,
 - Detector SC-SO₂/n - 0÷10 ppm SO₂,
 - Detector SC-HCN/n - 0÷20 ppm HCN.

Detectors' measuring errors correspond to the requirements of the regulations and technical data of the sensors. Detectors operates in stationary mode. They can perform function of two-threshold device intended for control-tripping out the external devices. Disconnecting thresholds are variable and can be set, while the highest threshold value corresponds to the MAC value for a given gas.

Oxygen detector SC-O₂/* (fig. 1.6) is intended for continuous measurement of oxygen concentration within the range from 0% O₂ to 25% O₂ (for basic version – n). The detector operates in stationary device mode. It is equipped with a possibility to set two alarm thresholds, which are possible to be set within the range from 19% O₂ to 21% O₂. Exceeding of threshold values can cause adequate activation of the external devices.

This sensor is manufactured in the basic version (n), or on the customer's demand can be manufactured in version s. Measurement error within the basic version is equal to 0.3% O₂. Response time T₉₀ is not longer than 10 seconds.

The following devices are intended for measurement of physical parameters of the ventilation network.



Fig. 1.6 Oxygen meter

Mining regulations require use of the stationary anemometers in the ventilation areas of the longwalls with presence of methane. The basic requirements for these instruments are: specification of direction and velocity of air flow. The second requirement is a possibility to switch off the voltage of external devices as a result of decrease of velocity of air or reversion of air flow. The below presented anemometer (fig. 1.7) is manufactured by Instytut Mechaniki Górniczej PAN in Cracow and the exclusive distributor is CARBOAUTOMATYKA S.A.

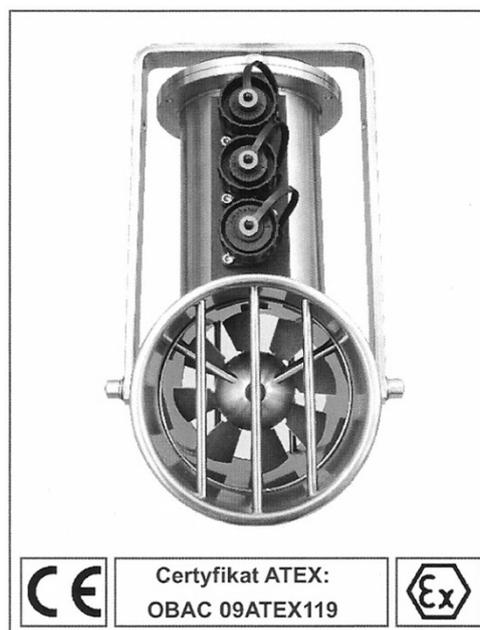


Fig. 1.7 Stationary vane anemometer MPP

Vane detector is used as a measuring element in the MPP-type anemometer. This device is able to detect direction of air flow. Range of measured velocity values is equal from 0.20 m/s to 20.00 m/s, while the real operation range can be defined. Measuring error of air flow velocity is equal to 0.5% of the measured value + 0.05 m/s.

Device is equipped with two outputs enabling control of the external devices. Characteristic feature of the anemometer is a possibility to record data in the internal memory. Real time

of performed velocity measurements and ambient temperature are recorded. Recording time is equal to 5 hours while the recording frequency is equal to 1 second.

Thanks to a possibility of internal supply, the device can be used for autonomous measurements of velocity in locations free from possibility of connection to the transmission-supply network. Internal supply time is equal to 1 hour.

Series of types of the detectors CPxx-x/x (fig. 1.8) is intended for measurement of the following parameters:

- Absolute pressure,
- Pressure difference,
- Air temperature,
- Air humidity,
- Rock mass temperature.



Fig. 1.8 Series of types of the detectors for measurement of physical parameters of the air

Name of the detector includes, after designation CP, two-letter abbreviation of detector's type, then after dash - number indicating measuring range, and after slash - version of the detector.

The following designation of the detector's type are recognized:

- Absolute pressure -CB,
- Pressure difference - RC,
- Air temperature - TP,
- Air humidity - RH,
- Rock mass temperature - TG.

Measuring range is indicated by:

- 1 - basic range (standard),
- 2 - non-standard range.

Version of the detector is indicated by:

- F - frequency version,
- U - voltage version,
- I - current version.

CARBOAUTOMATYKA S.A. company does not manufacture bi-state detectors, however such detectors, manufactured by other companies, can be connected to the KSP system.

Connection of a wide range of binary detectors is ensured by underground exchanged of bi-state signals CDS-2 (fig. 1.9).

Tab. 1.2 Measuring ranges and measurement errors of the detectors

Detector type	Measuring range	Measurement error
Absolute pressure -CB,	900 ÷1150 hPa	0,3 hPa
Pressure difference - RC,	15÷100 hPa	0,3 hPa
Air temperature - TP,	-20÷500C	0,50C – within the range 0÷400C 10C – within the range -20÷00C 10C – within the range 40÷500C
Air humidity - RH,	0÷100% relative humidity	2% of relative humidity
Rock mass temperature - TG	0÷1500C	10C – within the range 0÷1000C



Fig. 1.9 Underground exchange of bi-state signals CDS-2

This exchange cooperates with the KSP units. When the transmission is broken then the exchange will use internal autonomous source of supply. Supply from fully charged accumulator battery is enough for operation for approximately 8 hours. The unit switched off when the battery is used up.

Exchange can also operate without connection to the transmission line of KSP unit. In such case it should be connected to the external intrinsically safe power unit.

1.3 Example of detectors arrangement in the longwall's ventilation area

Methane hazard is the most important atmospheric hazard present in the methane mines. However hazard of the exogenic fires is always present. Also endogenic fires hazard is often present. Moreover in some mines there is a hazard of bounce, which can cause strong amplify of methane hazard as well as fires hazard, mainly exogenic fires. Hazard of non-maintaining of ventilation stability is always present but in different degree.

Not only primary hazards but also coexisting hazards should be taken into account during construction of the safety system.

Polish mining regulations [1] require use of three detectors for methane measurement in the longwall's ventilation area in case of methane mines:

- On wall's inlet. This detector is located on the longwall, up to 10 m from the working or in case when the longwalls have height lower than 1.5 m it is located in the working in the distance not bigger than 10 m from inlet to the longwall. A allowable concentration of the methane in the detector's location is equal to 1%.
- On wall's outlet. This detector is located in the distance up to 10 m from the outlet from the longwall in the working, or when two air streams are connecting on the longwall's outlet - then this detector is located in the longwall within 2 meters from the working. A allowable concentration of the methane in the detector's location is equal to 2%.
- On the outlet from ventilation area of the longwall. This detector is located in the working discharging dead air from the longwall between longwall's outlet and crossing with other working. A allowable concentration of the methane in the detector's location is equal to 1,5%.

More methanometric detectors is most often located in mines where there is a lot of methane present in the longwall's area.

Example of detectors' arrangement in the area of C-3 longwall is presented on the fig. 1.10. Presented longwall was located on the bed classified as fourth category of methane hazard, B class of coal dust explosion hazard, third group of self-ignition as well as third degree of bounce hazard.

Fresh air is supplied by transport inclined drift C to C-5 heading and then to longwall C-3. Dead air is discharged from longwall by C-4 heading, C-3 heading and then by C-3a heading to transport inclined drift and then by this inclined drift to dead air's ducts.

Methanometric detectors has been designated with the following numbers: 2, **6**, 7, 8, 9, **10**, 12, 13, 14, **15**, 18. Detectors designated with bolded font, that is **6**, **10** and **15**, are obligatory according to the current regulations. Other detectors are additional.

Detector **6** records methane concentration in current flowing in to the longwall. On the basis of its indications it is not possible to obtain exact location of the methane source in case when the allowable methane concentration (1%) is exceeded. Installation of detector 2 enables to separate ducts supplying fresh air into two sections. If the detectors **6** and 2 will simultaneously indicate exceeding of an allowable methane concentration, then methane inflow to fresh air current takes place in workings with fresh air located in front of location of installation of detector 2. If only detector **6** is signalling exceeding of the methane concentration then me-

thane inflow had occurred in heading C-5. In view of significant bounce hazard such information is important and can testify for dangerous increase of seismicity near the longwall.

Detectors 7, 8 and 9 are installed on the final section of the longwall.

Detector 7 is located 10 m from connection of the longwall with heading C-4, while detector 5 is located on the edge of longwall's powered roof support. Location of these detectors is the result of expected increased methane outflow in these locations.

Detector 9 is located over auxiliary drive of longwall conveyor, from workings side. It is the most possible location of methane explosion initiation.

Detector **10** is located according to the regulations. A allowable concentration of the methane in the location of detectors 7, 8, 9 and **10** is equal to 2%. Detectors 12, 13 and 14 are located in out of operation workings' sections ventilated by means of diffusion, located behind the ventilation stoppings (TI-1, TI-2 and T-3). In such locations methane can accumulate in concentrations over 2% that is over an allowable concentration.

Detector **15** is installed from 10 m to 15 m from crossing of C-3a heading with transport inclined drift C. An allowable methane concentration in location of detector's installation is equal to 1.5 %.

Detector 18 was installed between ventilation stopping TI-4 and transport inclined drift C. Working's section is also ventilated by means of diffusion. Because in the workings of ventilation area located behind place of installation of the detector measuring concentration on the outlet from area (detector **15**), an allowable concentration in place of installation of detector 18 is equal to 1.5%.

From the presented arrangement of the detectors it arises that main ventilation engineer thinks that fulfilment of the safety requirements requires installation of 11 methane concentration detectors, while fulfilment of the regulations will require installation of only three.

Five carbon monoxide detectors were installed in order to monitor degree of fire hazard in the C-3 longwall's area. These detectors are designated with numbers 1, 5, 11, 16 and 19.

Detector 1 is located on the inlet to heading C-5. It is intended to detect exogenic fire in the bud in the fresh air current flowing in to the heading C-5.

Detector 5 is installed in place of connection of belt conveyor and scraper conveyor. When the exceeded carbon monoxide is indicated by detector 5 and simultaneously there is no indication of exceeded carbon monoxide concentration by detector 1, it should be supposed that there can be a source of exogenic fire in the heading C-5 between the listed detectors.

Increased indications of the carbon monoxide concentration by detector 11 with indication of normal situation by detector 5 can testify about a starting exogenic fire between detectors 5 and 11 or about increase of endogenic fire hazard in the longwall C-3.

Increase of CO concentration in place of installation of detector 16 and normal CO concentration indicated by detector 11 testifies about possible exogenic fire in headings C-4, C-3 or C-3a, or about CO outflow from behind ventilation stoppings TI-1, TI-2 or TI-3.

Elevated concentration of carbon monoxide indicated only by detector 19 can testify for flowing out of carbon monoxide from behind ventilation stopping TI-4 or about beginning fire in transport inclined drift C.

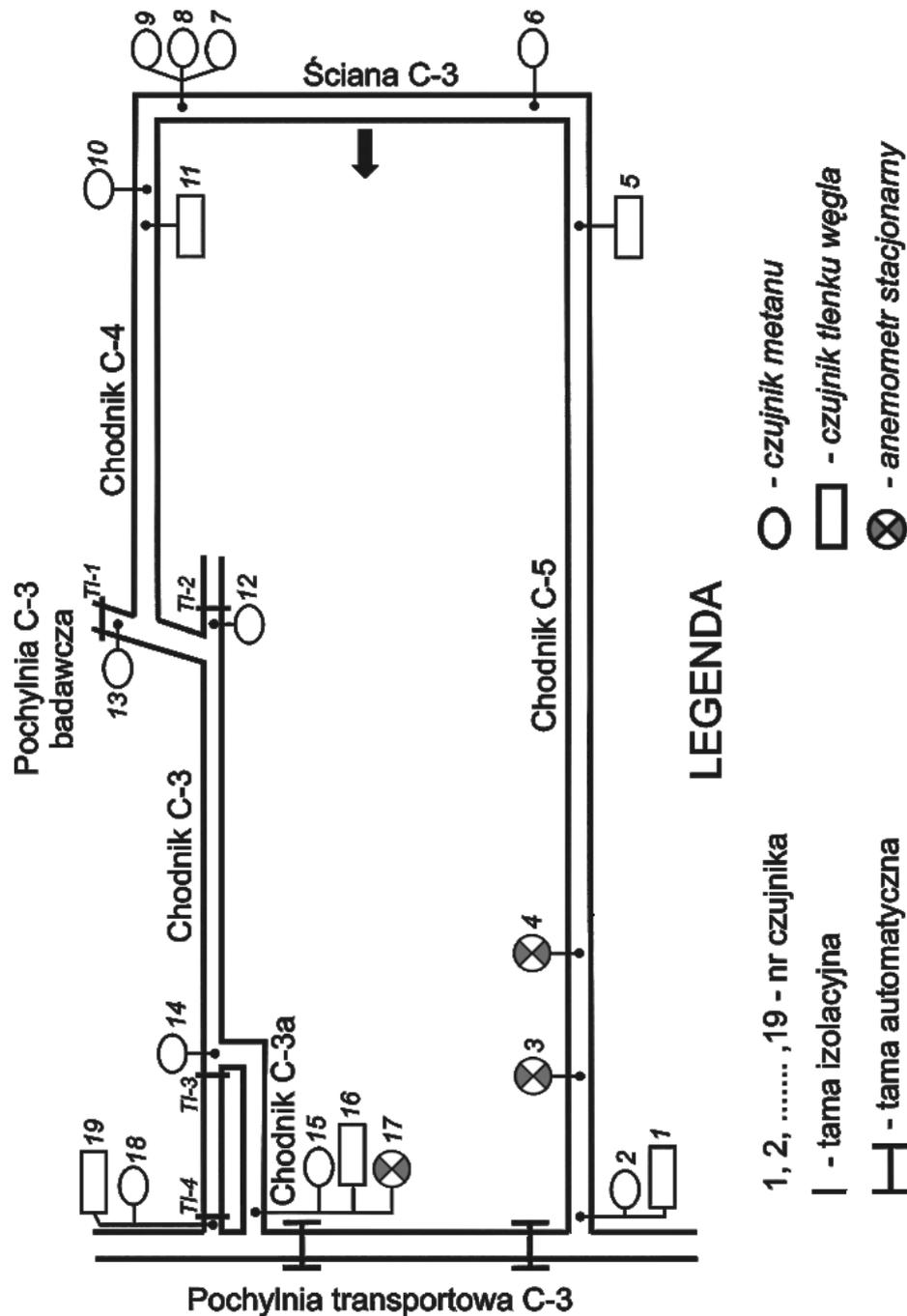


Fig. 1.10 Example of detector's arrangement in the longwall

Also three stationary anemometers are installed in the area of C-3 longwall. Two of them are located in C-5 heading while third is installed in heading C-3a. The anemometers are intended for switching off electric energy in the longwall's area when the velocity decreases below threshold set. Switching off electric energy should not take place too often because the anemometers are sensitive to instantaneous disturbances of air velocity. Anemometers' doubling (anemometers 3 and 4) and simultaneous analysis of signals from both anemometers enables to eliminate unjustified switching off electric energy in the area of the longwall.

Winning transport on bands is carried out in the longwall's heading as well as materials transport (as support) what cause that measurement of the working's cross-section surface and

manual measurement of average air velocity are subject to significant error. It is also a reason of big error in calculations of methane quantities in the longwall's area. The listed measurements are much more precise after placing the stationary anemometer on the outlet of this area. It is a main reason of location of the anemometer 17 on the outlet of the longwall's area. This anemometer is indispensable to determine volume flow of the air on the outlet from this area in case when machines and devices driven by compressed air are operating in the area as well as when refreshing of air stream flowing out from the longwall by air stream supplied to longwall's outlet by ventilation pipe, which fan is located in the fresh air current.

The mining regulations requires use of one anemometer for control of air stream through a longwall. Airlock, constructed of two automatic stoppings in transport inclined drift C is equipped with protections making impossible to open simultaneously both stoppings. Simultaneous opening of both stoppings will result in connection through a inclined drift what will cause a significant increase of methane concentration in the longwall and the heading.

In consequence safety system of the longwall C-3 consists of 20 sensors that is almost seven-times more than minimum specified by the mining regulations.

1.4 Summary

Working environment plays a very important part in human life. In case of underground miner's work the working environment has a lot of hazards caused by geosphere, technosphere as well as atmosphere.

Counteraction against atmospheric hazards in underground workings is based mainly on preservation of proper parameters of air composition and physical parameters of the air. Telemetrical systems in Polish mines are subject to intense development from the early 90s of the 20th century. Such systems are intended for automatic measurement of atmospheric air composition as well as its physical parameters. PKiMSA CARBOAUTOMATYKA S.A. from Tychy is one of the companies which had noticed a need to develop multi-directional telemetrical systems. Offer of the CARBOAUTOMATYKA company includes surface telemetrical units, underground units for measurements of chemical parameters as well as physical parameters of the mine atmosphere. Sensing elements operate in the continuous mode while theirs construction enable direct or indirect (after signal's sending to the surface unit) control of external devices, e.g. intended for switching off electric energy in the specified areas of the mine.

Measured chemical parameters are concentrations of the following gases: methane, carbon monoxide, carbon dioxide, hydrogen sulfide, ammonia, nitrogen monoxide and nitrogen dioxide, chlorine, sulphur dioxide, hydrogen cyanide as well as oxygen.

Air velocity, absolute pressure, pressure difference, temperature and air humidity are calculated from among physical parameters. Moreover also a rock mass temperature can be measured. This temperature is a basic parameter in heat transfer theories from rock mass to the workings.

The mining regulations imposes some measurements of physical and chemical parameters. However fulfilment of regulations requirements gives the necessary minimum safety. More extended safety system is usually used in the mines than it can arise from the regulations and the extension degree depends on evaluation of hazards present.

Manual measurements are still inalienable supplementation of the telemetrical measurements. Such manual measurements are carried out in all locations of potential presence of hazard source.

Development of the automatic measuring systems and devices intended for individual measurements should be connected with development of measurements interpretation method in order to anticipate beforehand a degree of potential hazard and to plan suitable hazard prevention mechanisms.

REFERENCES

- [1] The regulation of the Minister of Economy of 28th June 2002 (Journal of Laws no. 139, item 1169 as amended) on occupational safety and health, operation and specialist fire protection in the underground mining enterprises.
- [2] Informative materials of PKiMSA CARBOAUTOMATYKA S.A.