All-Russian Classification
of Products 42 1541

Process Gas Chromatograph MAG

of the model KC50.310-000-01

OPERATION MANUAL

KC 50.310-000-01 RE

V 3.0

Samara 2017

CONTENTS

INTRODUCTION

This operation guide covers the process gas chromatograph MAG of general industrial model KC 50.310-000-01 (hereinafter referred to as the chromatograph) designed for continuous automatic determination of concentration of organic and inorganic substances in the gas mixtures, liquefied gases and liquids.

CAUTION!

Before you begin to use the chromatograph MAG, you should read the operation manual carefully. It contains chromatograph operational guidelines and rules on operation, connection, adjustment, maintenance, transportation, storage and conditions for chromatograph warranty repair.

The Manufacturer guarantees reliable operation of the chromatograph and acquisition of reliable measurement results only in strict observance of requirements and recommendations of this operation manual.

The manufacturer may make minor changes in the chromatograph construction that do not deteriorate technical, metrological and performance characteristics of the device. They may not be described in the operation manual.

Manufacturer:

STF “BACS” LLC (Scientific and Technical Firm "BACS", Ltd.), Russia.
Address: 443022, Samara, Kirova ave., 10.
Tel.: +7 (846) 267-38-12;
e-mail: info@bacs.ru
Web-site: www.bacs.ru.

1. DESCRIPTION AND OPERATION

1.1. PURPOSE

1.1.1. Process gas chromatograph MAG model KC 50.310-000-01 is intended for determination of the blend composition of gases, liquefied gases and liquids.

1.1.2. The list of components that can be analyzed with the MAG GC:

- Permanent gases: He, H_2, N_2, O_2, CO, CO_2;
- Inorganic compounds: H_2O, H2S, COS, SO_2, NH_3, N_2O, NOx, etc.;
- Saturated hydrocarbons: methane, ethane, propane, butanes, etc. up to n-decane;
- Unsaturated hydrocarbons: ethylene, acetylene, propylene, propadiene, methylacetylene, butylenes, butadiene, etc.;
- Aromatic hydrocarbons: benzene, toluene, ethylbenzene, xylenes, etc.;
- Oxygenated organic compounds: alcohols (methanol, ethanol, TMC (trimethyl carbinol), etc.), glycols, ethers and esters (dimethyl ether, MTBE, TAME, etc.), aldehydes (acetic aldehyde, acrolein, etc.), ketones, fatty acids;
- Halogen-containing compounds, nitrogen-containing compounds and other polar volatile organic compounds;
- Sulfur-containing organic compounds: mercaptans, sulfides, disulfides.

1.1.3. Gas chromatograph is designed for continuous operation in process automatic mode.

1.1.4. The chromatograph is supplied with a system of several separation columns included in the changeable analysis channels. Depending on the applications performed, the chromatograph is supplied with a different number and type of the analytical channels, each of which includes:

- Detector;
- The system of chromatograph columns;
- Diaphragm valve or injector-vaporizer.

Each analytical channel is an independent thermostatted zone. The maximum number of analytical channels in the chromatograph is up to four.

1.1.5. The following gas parameters can be calculated by the firmware (software) of the chromatograph (depending on the model of the device) with the help of the computational algorithm:

- volume, mass and mole fraction of the component;
- mass concentration of mercaptan sulfur;
- mass fraction of the total sulfur.

1.1.6. The chromatograph is equipped with the detectors of following types:

- Thermal conductivity detector (**TCD**) – universal detector which provides measurement of any inorganic and organic compounds within the range of concentrations from 5 ppm to 100%;
- Catalytic combustion detector (**CCD**) – selective detector with the increased sensitivity which allows to conduct measurement of concentrations of hydrogen, oxygen, CO, hydrocarbons and other organic substances which are able to be oxygenized on the sensitive elements of the detector within the range of concentrations from 0,5 ppm to 5%;
- Electrochemical detector (**ECD**) – high sensitive specific detector for sulfur containing compounds (hydrogen sulfide, mercaptans, sulfides) which allows to determine them with minimum interference with other compounds within the range of concentrations from 0,05 ppm to 1%.

1.1.7. The chromatograph can be equipped with packed, micropacked and open-tubular (capillary) columns and their combinations.

1.1.8. The chromatograph can be equipped with injector-vaporizer or liquid sampling valve for liquefied gas (without preliminary vaporization of gas) or liquid sample injection.

1.1.9. The chromatograph can be used in the system of custody transfer and gas quality control on the gas-measuring and gas-distribution stations, automatic control systems and process control of oil refining, petrochemical, gas processing and other businesses.

Examples of chromatograph application:

- Analysis of the blend composition of natural gas and associated gas according to ISO 10723 and ISO 6974 (GOST 31371.7-2008) followed by the calculation of its physicochemical parameters according to ISO 6976 (GOST 31369-2008);
- Analysis of the liquefied natural gas (LNG) and boil-off gas (BOG) composition;
- Analysis of the mass concentration of sulfur-containing compounds in natural gas according to ISO 19739 (GOST R 53367-2009), associated gas and other substances;
- Analysis of natural gas liquids (NGL) and liquefied petroleum gases (LPG) which includes the quality control of liquid and gaseous commercial products on gas fractionation plants;
- Analysis of natural gasoline, gas condensate and dry stripped gas composition;
- Determination of methanol and other oxygenates in different hydrocarbon substances;
- Quality control of raw materials and products on MTBE and TAME plants;
- Control of the operation of manufacturing plants and analysis of commercial products in the production of olefins (ethylene, propylene, butylene fractions);
- Analysis of process streams and commercial products in the production of rubbers including control of operation of isoprene production units;

- Analysis of various products of organic synthesis processes;
- Analysis of hydrogen containing gas;
- Analysis of synthesis gas, coal-derived gas, pyrolysis products;
- Analysis of permanent gases;
- Analysis of natural gas of variable and extended composition (as per certificated measuring techniques).

The above list is by no means comprehensive. Fill in the questionnaire and contact the manufacturer to know if the chromatograph MAG matches your particular application.

1.1.10. The chromatograph has an explosion-proof design, meets the requirements of the Customs Union Technical Rule TR CU 012/2011 “On safety of the equipment operating in explosive atmospheres”, IEC 60079-0:2011 (GOST 31610.0-2014), IEC 60079-1:2007 (GOST IEC 60079-1-2011), IEC 60079-11:2011 (GOST 31610.11-2014) and can be installed in explosion-proof areas according to Electrical Installation Standard, ed.6 chapter 7.3 2001, IEC 60079-10:2002 (GOST R 31610.10-2012) according to the marking of explosion protection.

Explosion-proof marking – 1Ex d IIB+H2 T4Gb or 1Ex d IIB T4 Gb (depending on the type of explosion-proof enclosure)

Installation zone – 1.

Explosion protection – explosion-proof enclosure (d).

Subgroup of electrical equipment – IIB or IIB+H2

Temperature class – T4.

1.2. TECHNICAL SPECIFICATIONS

1.2.1. PARAMETERS OF THE GAS SUPPLY

1.2.1.1. The chromatograph operation requires the supply of pure gas used as carrier gas. The parameters of the carrier gas used with the chromatograph MAG are shown in Table 1.

Table 1. Parameters of the gas supply

The type of detector	Carrier gas	The pressure of carrier gas, MPa	Gas flow rate, cm^3/min
TCD	Helium, no worse than grade 4.5 (99,995%)	From 0.5 to 0.6	From 5 to 30
	Argon, no worse than grade 4.5 (99,995%)		
	Nitrogen, no worse than grade 4.5 (99,995%)		
	Hydrogen, no worse than grade 4.5 (99,995%)		
ECD	Synthetic air, no worse than grade 4.5 (99,995%)		
CCD	Helium, no worse than grade 4.5 (99,995%) Synthetic air, no worse than grade 4.5 (99,995%)		

Note: *the selection of the type, pressure and flow rate of the carrier gas depends on the analysis method. Several types of carrier gases can be used with one chromatograph simultaneously.*

Carrier gas supplied to the chromatograph should be dry and free of particles.

1.2.1.2. The chromatograph MAG is designed for the analysis of gases, liquefied gases and liquids which have following parameters:

- the temperature of the analyzed mixture at the inlet of the chromatograph is (0-150) °C;
- mechanical impurity concentration in the analyzed mixture shall not exceed 10 mg/m^3 at particle size less than 5 micron;
- the analyzed gas shall not contain suspended particles of liquid in the form of aerosol;
- the boiling temperature of liquid samples directly injected with the help of the vaporizer shall not exceed 150°C;
- the sample pressure of the analyzed gas at the inlet of the chromatograph shall be from 0.04 to 0.1 MPa. It provides sample flow rate through the sample loop of the chromatograph at the level of 50 – 150 cm^3/min;
- the liquid sample pressure at the inlet of the vaporizer of the chromatograph shall not exceed 7 MPa.

The gas lines of the chromatograph are leakfree at pressure equal to 1.2 from the maximum operating value (Table 1). Pressure drop for 30 min – not more than 0.015 MPa.

1.2.2. TECHNICAL SPECIFICATIONS

The main technical specifications are shown in Table 2.

Table 2. The main technical specifications

<table>
<tr><th colspan="2">Parameter name</th><th colspan="2">The value and characteristic of the parameter</th></tr>
<tr><td colspan="2">Number of the analytical channels</td><td colspan="2">Up to 4</td></tr>
<tr><td colspan="2">Type of detector</td><td colspan="2">Thermal conductivity detector (TCD)
Electrochemical detector (ECD)
Catalytic combustion detector (CCD)</td></tr>
<tr><td colspan="2">Oven type</td><td colspan="2">Airless, isothermal</td></tr>
<tr><td colspan="2">Temperature of the oven</td><td colspan="2">60–150°C</td></tr>
<tr><td colspan="2">Type of chromatograph columns</td><td colspan="2">Open-tubular (capillary), micropacked, packed</td></tr>
<tr><td colspan="2">Carrier gas pressure regulator</td><td colspan="2">Electronic/mechanical</td></tr>
<tr><td colspan="2">Pressure and flow rate of carrier gas</td><td colspan="2">Pressure 0.5 - 0.6 MPa; flow rate: 5 - 30 cm^3/min</td></tr>
<tr><td colspan="2">Phase of analyzed mixture</td><td colspan="2">Gaseous, liquefied gas and liquid</td></tr>
<tr><td colspan="2" rowspan="2">Pressure and flow rate of a sample</td><td>Gas</td><td>Liquid / liquefied gas</td></tr>
<tr><td>Pressure: 0.04 - 0.1 MPa
Flow rate: 50 - 150 cm^3/min</td><td>Pressure: not more than 7 MPa</td></tr>
<tr><td colspan="2">Volume of sample loop</td><td colspan="2">5 – 1000 μl (depending on an application)</td></tr>
<tr><td colspan="2">Analysis duration</td><td colspan="2">From 1 to 30 min (depending on an application)</td></tr>
<tr><td colspan="2">Number of analyzed streams</td><td colspan="2">up to 6 (including test gas mixture)</td></tr>
<tr><td colspan="2">Chromatograph calibration</td><td colspan="2">Automatic (by test gas mixture)</td></tr>
<tr><td colspan="2">Data input-output device</td><td colspan="2">12” LCD sensor display (optionally)</td></tr>
<tr><td rowspan="2">Communication interfaces</td><td>Standard</td><td colspan="2">RS 232/485 (ModbusRTU) – 2 pcs.,
Ethernet (ModbusTCP) – 1 pc.,
Discrete inputs (NAMUR) – 4 pcs. (optionally extendable)</td></tr>
<tr><td>Optional</td><td colspan="2">RS 232/485 – extra 1 pc., 4-20 mA – up to16 pcs.,
Discrete outputs, optical Ethernet, GSM/GPRS</td></tr>
<tr><td colspan="2">Power voltage</td><td colspan="2">220^{+22}_{-33} V and with frequency (50±1) Hz</td></tr>
<tr><td colspan="2">Power consumption</td><td colspan="2">at the warm-up – not more than 180* W;
after the warm-up – not more than 80W.</td></tr>
<tr><td colspan="2">Classification of explosion protection</td><td colspan="2">1Ex d IIB T4Gb or 1Ex d IIB+H2 T4 Gb</td></tr>
<tr><td colspan="2">Ingress Protection Marking</td><td colspan="2">IP65 as per IEC 60529:2013</td></tr>
</table>

Parameter name	The value and characteristic of the parameter
Ambient temperature, °C	from -10 to +50 °C at atmospheric pressure 84.0-106.7 kPa, at atmosphere relative humidity not more than 95% without humidity condensation
Dimensions (length×width×height), mm	400×300×481 436×318×607**
Weight not more than, kg	40 58*
* May vary depending on configuration for the GC. Maximum power consumption of the particular version of GC specified in the technical passport of the instrument. ** depending on version	

1.2.3. METROLOGICAL CHARACTERISTICS

Metrological characteristics are shown in Table 3.

Table 3. The metrological characteristics of the chromatograph MAG KC 50.310-000-01

The name of metrological characteristics	Detector	The volume of metrological characteristics
Fluctuation noise level, V, not more than	TCD ECD CCD	$2 \cdot 10^{-6}$ $2 \cdot 10^{-6}$ $2 \cdot 10^{-6}$
Base-line drift per hour, V, not more than	TCD ECD CCD	$6 \cdot 10^{-5}$ $1{,}5 \cdot 10^{-5}$ $6 \cdot 10^{-5}$
Detection limit, g/cm^3, not more than	TCD for nitrogen, propane or hexane with carrier-gas helium or hydrogen	$4 \cdot 10^{-9}$
	TCD for hydrogen or helium with carrier-gas argon or nitrogen	$1 \cdot 10^{-9}$
	TCD for propane or hexane with carrier-gas argon or nitrogen	$5 \cdot 10^{-8}$
	ECD for hydrogen sulfide	$1{,}5 \cdot 10^{-11}$
	ECD for ethyl mercaptan	$3 \cdot 10^{-11}$
	CCD for hydrogen	$2 \cdot 10^{-10}$
	CCD for propane	$5 \cdot 10^{-10}$
The relative standard deviation limit of output signal (peak area), % not more than	TCD (for liquid sample injection)	2
	TCD (for gaseous sample injection)	1
	ECD	2
	CCD	1
The relative variation of output signal (peak area) for 24 hours of continuous operation, % not more than	TCD	3
	ECD	4
	CCD	3

1.2.4. The warm-up time of the chromatograph is not more than 60 min.

1.2.5. Reliability indicators.

Mean time between failures – 10000 hours;

The average total service life of the chromatograph – 10 years.

1.2.6. The list of the measured components of analyzed mixture and their measurement ranges as well as configuration and values of operating parameters are presented in the Appendix A to the operation manual for a specific chromatograph.

1.3. CHROMATOGRAPH COMPLETENESS

Table 4. Chromatograph Completeness

Designation	Name	Number
KC 50.310-000-01	Process Gas Chromatograph MAG	
	SPTA (in the completeness according to the certificate)	
	Calibration mixture cylinder	
KC 50.310-000-01 RE	Operation manual with the Appendix	
KC 50.310-000-01 PS	Technical passport	
	Operator’s guide for “Analyzer” software	
	Operator’s guide for “Analyzer.Network” software	
	Installation software on digital storage medium	
	Verification methods	
	The copy of Pattern approval certificate	
	The copy of the Explosion protection certificate	

Chromatograph completeness is presented in the chromatograph Certificate

1.4. COMPLIANCE WITH EXPLOSION PROTECTION REQUIREMENTS

1.4.1. GENERAL INFORMATION

Process gas chromatograph MAG is explosion-proof equipment.

1.4.1.1. The chromatograph can be installed in the zone 1 according to IEC 60079-10:2002 (GOST R 31610.10-2012).

1.4.1.2. Subgroup of electrical equipment: IIB or IIB+H2.

1.4.1.3. Temperature class: T4.

1.4.1.4. Following types of explosion protection are applied:

- flameproof enclosure d according to IEC 60079-1:2014 (GOST IEC 60079-1-2014).

1.4.1.5. Explosion-proof marking – 1Ex d IIB+H2 T4Gb or 1Ex d IIB T4 Gb (depending on the type of explosion-proof enclosure).

1.4.1.6. Constructional and organisational measures are applied to ensure compliance with explosion protection requirements

1.4.2. CONSTRUCTIONAL MEASURES.

1.4.2.1. All chromatograph blocks are located in the enclosure of a high degree of mechanical strength SchORV423229-O3020 or SchORV654533-O3020 (OOO “Zavod GORELTEH”) or BXT-IVB or BXT-VIB (“Warom”) able to withstand the pressure of internal explosion without damage and prevent flame propagation outside in accordance with IEC 60079-1:2014 (GOST IEC 60079-1-2014). Enclosure volume is 0.02 m^3 or 0.05 m^3 depending on version.

1.4.2.2. The pressure inside the explosion-proof enclosure shall not exceed atmospheric pressure. The ventilation device VKU1M (LLC “Zavod GORELTEH”) or BPS(H) (”Warom”) releasing excessive pressure in case of depressurization of the gas paths is installed to equalize the pressure. Also the absolute pressure sensor, which measures the pressure inside the explosion-proof enclosure, is set inside the enclosure. In case of absolute pressure inside the box exceeds 1.1 bar the electrical power of the chromatograph is turned off.

1.4.2.3. Cable entry into the box is made with the help of certified explosion-proof cable glands of types KHB1N, KOB1N, KOB12N (LLC “Zavod GORELTEH”) or DQM-IIExd (”Warom”). The application of cable glands of this type does not require potting due to their long elastomer O-ring. Cable glands are located on side and lower walls of the device. Unused cable glands are plugged with the help of certified explosion-proof plugs of type B3H1RH (1/2) (LLC “Zavod GORELTEH”) or BPT-Rc1/2(”Warom”).

1.4.2.4. Flameproof enclosure, cable glands, ventilation device are the products of LLC “Zavod GORELTEH” (Russia) or “Warom Technology Incorporated Company” (China) and have current quality certificates.

1.4.2.5. The gas lines entry is performed through the flame arresters certified as parts of the chromatograph. Slot-type flame arresters have the maximum possible clearance according to IEC 60079-1:2014 (GOST IEC 60079-1-2014). Their structure is shown in the assembly drawing.

1.4.2.6. If necessary, heated flame arrester is used to heat gas inlets. It consists of a heater, a temperature sensor included in the circuit of the heater control device feedback and also a temperature switch for overheat protection.

1.4.2.7. The protection against overheat above 135 °C corresponds to the temperature class T4 and is provided by a temperature switch included in protection board circuit. When temperature corresponding to the T4 temperature class is reached, chromatograph power supply voltage is turned off.

1.4.2.8. The power of chromatograph main blocks (except for heating elements) is provided by 24V voltage. The built-in power supply is used to generate this power.

1.4.3. ORGANISATIONAL MEASURES

1.4.3.1. The plate with the information about type and parameters of explosion protection, manufacturer contact information is attached on the chromatograph housing.

1.4.3.2. The plate attached on the device housing contains a caution board: “Open after 30 minutes since power-off”.

1.4.3.3. The device is provided with grounding clamp.

1.4.3.4. The flame arresters of gas lines are located on the lower wall of the explosion-proof enclosure. Consequently, it is necessary to ensure that gas lines remain undamaged (without folds and wrinkling of gas lines, cracks, shears and other damages of gas fittings) during the transportation, verification and installation. Do not operate the device in explosive atmosphere if flame arresters have the above listed damages. Independent replacement, modification of the construction and repair of the elements are strictly prohibited. Only manufacturer’s specialists may perform the replacement of the flame arresters.

1.5. OPERATING PRINCIPLE OF THE CHROMATOGRAPH MAG

1.5.1. GENERAL INFORMATION

The gas chromatography method based on the separation of analyzed sample mixture in individual components in open-tubular (capillary), micropacked or packed columns is applied in the chromatograph.

The sample of analyzed substance in gaseous or vaporized state is injected with the stream of mobile phase (non-sorbing substance is chosen as carrier gas) into the chromatograph columns. The separation of analyzed sample in individual components happens due to their different distribution between stationary and mobile phases during the moving through the column. The sample components move out of the column in the stream of carrier gas. Their presence is recorded by the detector, which forms an electrical signal proportional to quantity of a component of a sample which reaches the detector's sensitive element at the outlet of the column.

The sample of analyzed substance is injected into the column periodically after the end of separation and the previous sample components escape from the column.

1.5.2. OPERATING PRINCIPLE OF TCD

Operating principle of thermal conductivity detector (TCD) is based on the changing of electrical resistance of thermosensitive elements depending on the changing of the thermal conductivity of gas flowing through the detector.

TCD consists of four (or two) thermosensitive elements. Two (or one) of them are set in cells through which the stream of gas from the column flows, and two (or one) other elements are set in cells through which pure carrier gas flows. Sensitive elements are included in the measuring bridge scheme and heated by current from special stabilized supply source. Temperature condition in cells is determined by current flowing through the sensitive elements, housing temperature and heat amount transferred to cell walls. Thermal balance is set in cells if mentioned parameters are constant.

The changing of the concentration of the sample components flowing through measure cells changes substance thermal conductivity in cells resulting in disturbance of thermal balance, temperature changing and resistance of thermosensitive elements. It causes disbalance of measuring bridge, by value of which it is possible to estimate the changing of the component concentration in carrier gas.

1.5.3. OPERATING PRINCIPLE OF ECD

Operating principle of electrochemical detector (ECD) is based on the generation of electrical current during the flowing through the detector of substances capable of oxidation — in this case, of hydrogen sulfide, mercaptans and sulfides. Diffusion ECD, in which gas is separated from electrolyte

and electrodes by thin membrane, is used in the device. The structure of the detector is shown in Fig. 1.

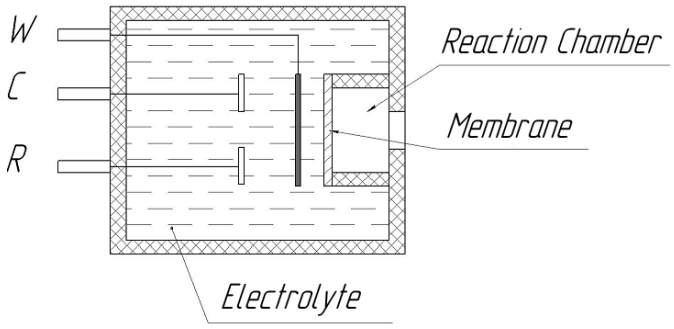


Fig. 1. The structure of electrochemical detector

Following sulfur compounds oxidation reactions can proceed on working electrode (indicated by letter W):

hydrogen sulfide	$H_2S + 4H_2O = SO_4^{2-} + 10H^+ + 8e$
mercaptans	$RSH + 3H_2O = RSO_3H + 6H^+ + 6e$
	$RSH + H_2O = RSO + 3H^+ + 3e$
	$2RSH = RSSR + 2H^+ + 2e$
Sulfides	$R_2S + 3H_2O = R_2SO_2 + 6H^+ + 6e$

Working electrode is covered with the layer of catalyst, thereby oxidation is gentle. The catalyst is selected in such a way as to not only sulfur-containing components are oxidized on it. ECD does not respond to hydrocarbons, nitrogen, carbon dioxide, which makes it convenient for determination of sulfur-containing compounds in natural gas.

Oxidizer reduction reactions occur at the decision electrode (indicated by the letter C). Atmospheric oxygen is used in ECD as oxidizer. At the same time, the following reaction occurs at the electrode:

$$2O_2 + 4H^+ + 4e = 2H_2O$$

For normal operation of the ECD, the oxygen content in the detector chamber should be at least 0.1 of the volumetric fraction, %. Provision of sufficient volume of oxygen for the reactions described above is usually carried out by using air as the carrier gas.

The third electrode is the reference one (indicated by the letter R) and serves to maintain the constant potential of the working electrode. In the diffusion-type ECD, the rate-controlling step is the diffusion of the defined components to the working electrode. In this case, detector current is proportional to concentration of the measured component in the gas *Ci*, to the diffusion coefficient *D* and to the number of electrons *n* according to the reaction equation:

$$I = D*n*Ci.$$

ECD of the membrane type does not require servicing during calibration interval. Maximum working temperature of ECD is not more than 50°C.

Note: *Moisture content in the working chamber at a level of relative humidity 15–90% is necessary for extended operation of ECD. Auxiliary gas line, which moistens the carrier gas, is introduced into the gas circuit for this.*

1.5.4. OPERATING PRINCIPLE OF CCD

Operating principle of catalytic combustion detector (CCD) is based on the change in the thermal effect during the catalytic combustion of sample components emerging from a chromatographic column on the surface of the sensitive element of the detector.

Sensing element of the CCD is a platinum spiral about 30 μm in diameter, pressed into a ball of Al_2O_3 with a diameter of about 1 mm. Surface of the ball is coated with platinum, palladium or thorium compounds, which have catalytic properties. Operating temperature of the element is 400–500 °C. At this temperature reaction of oxidation of combustible compounds with oxygen occurs at its surface, during which heat is released, that increases the temperature of the thread and, consequently, its resistance. The structure of the sensitive element of CCD is shown in the figure below.

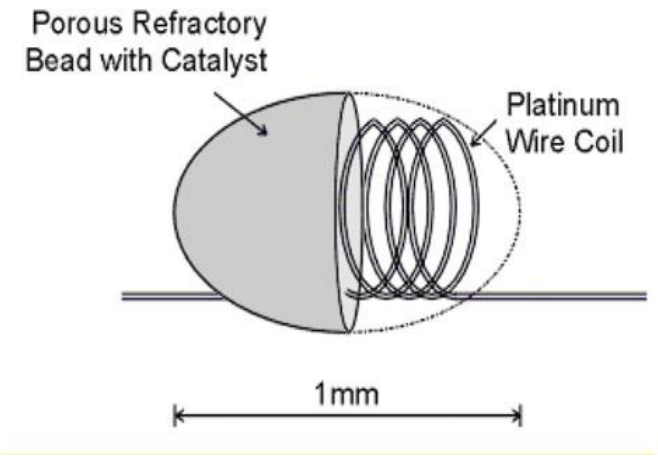


Fig. 2. The structure of the sensitive element of CCD.

Along with active sensing element, a comparative element with no catalyst layer — on which no combustion of the sample components occurs — is mounted in the CCD case. Sensitive and comparative elements are matched in pairs with the closest possible resistance values.

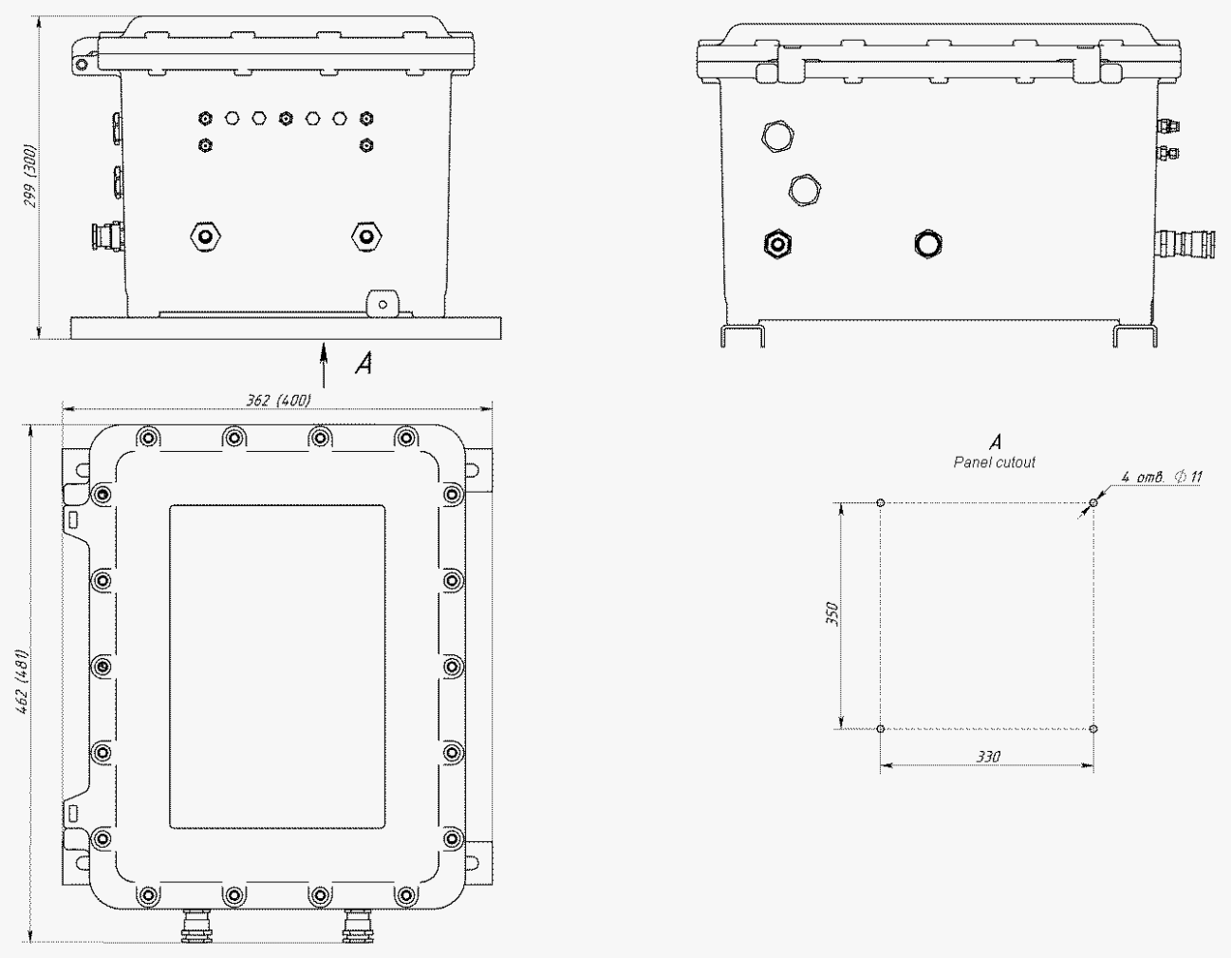
Output signal of the detector is conditioned by the difference of temperatures and, as a consequence, resistances of the sensitive and comparative elements in the presence of combustible gases. This difference — proportional to the concentration of the analyzed substance — is fixed by means of bridge circuit.

CCD is used for analysis of combustible substances (including hydrogen) only, its sensitivity to these compounds is higher than for TCD and is comparable to the sensitivity of FID.

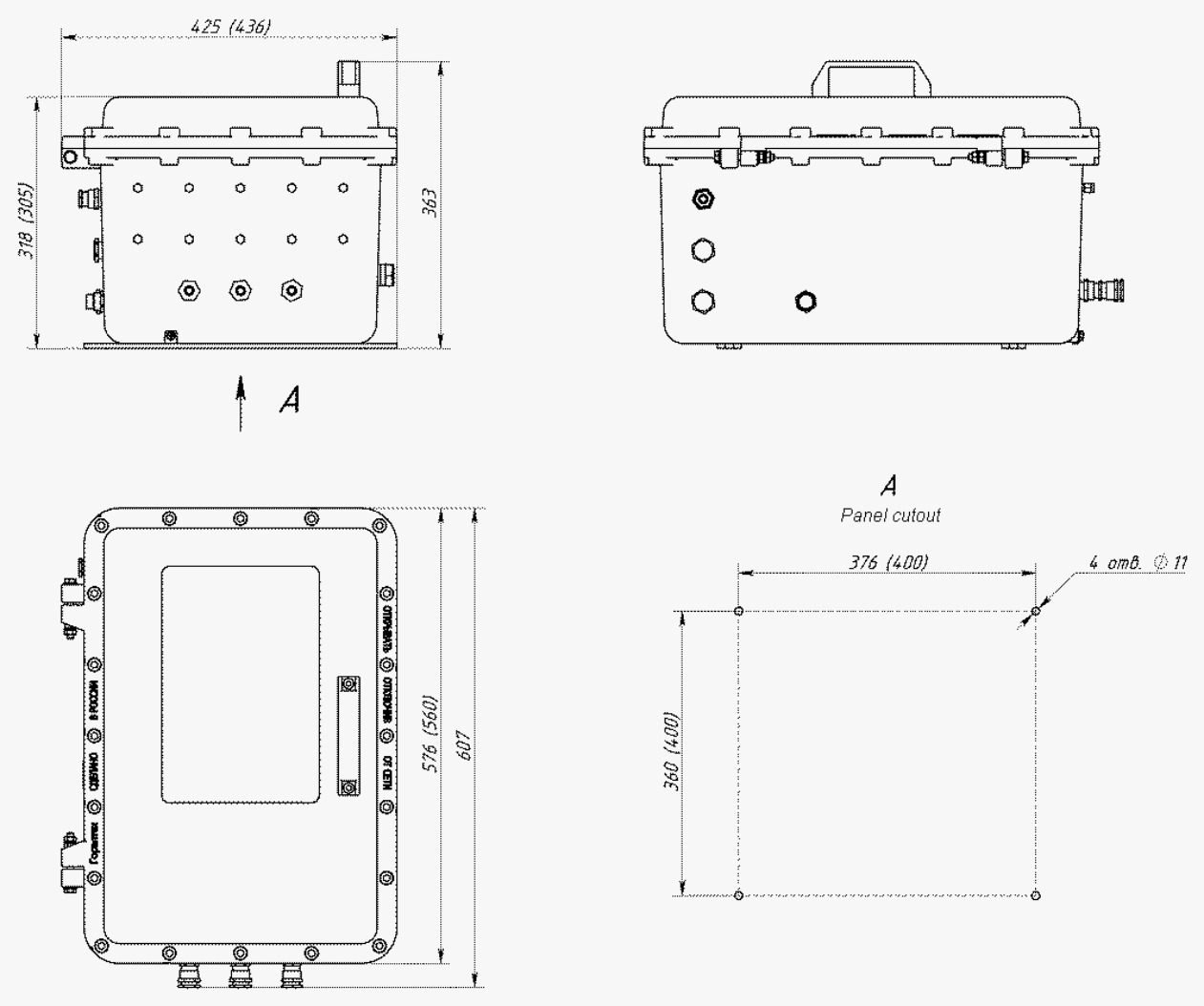
To provide the oxidation of sample components on the surface of the catalyst, air or helium with air-feeding is used as the carrier gas.

1.6. STRUCTURE AND OPERATION OF THE CHROMATOGRAPH MAG

Chromatograph MAG includes a set of functional blocks located in an explosion-proof enclosure, the appearance and dimensions of which are shown in Fig. 3 for different versions of the chromatograph.



a) For versions with 1 or 2 analytical channels



b) For versions with 3 or 4 analytical channels

Fig. 3. Appearance of the chromatograph MAG

Touchscreen, display and indicator panel are on the front panel behind the enclosure glass. The device may have a design without touchscreen and display, while the front cover of the explosion-proof enclosure is being "blank" (without window). Cable entries to connect external devices are on the side panel. In addition, there is a ventilation device on the side wall. Cable entries for the power cable of the device and for the data-output cable are located on the lower wall. In addition, there are gas inlets on the lower wall of the device. Heated gas inlets and injector-vaporizer may be also located at the side wall of the instrument.

1.6.1. INTERNAL STRUCTURE OF THE CHROMATOGRAPH "MAG"

The internal structure of the chromatograph with two analytical channels with the TCD and CCD detectors is shown in Fig. 4

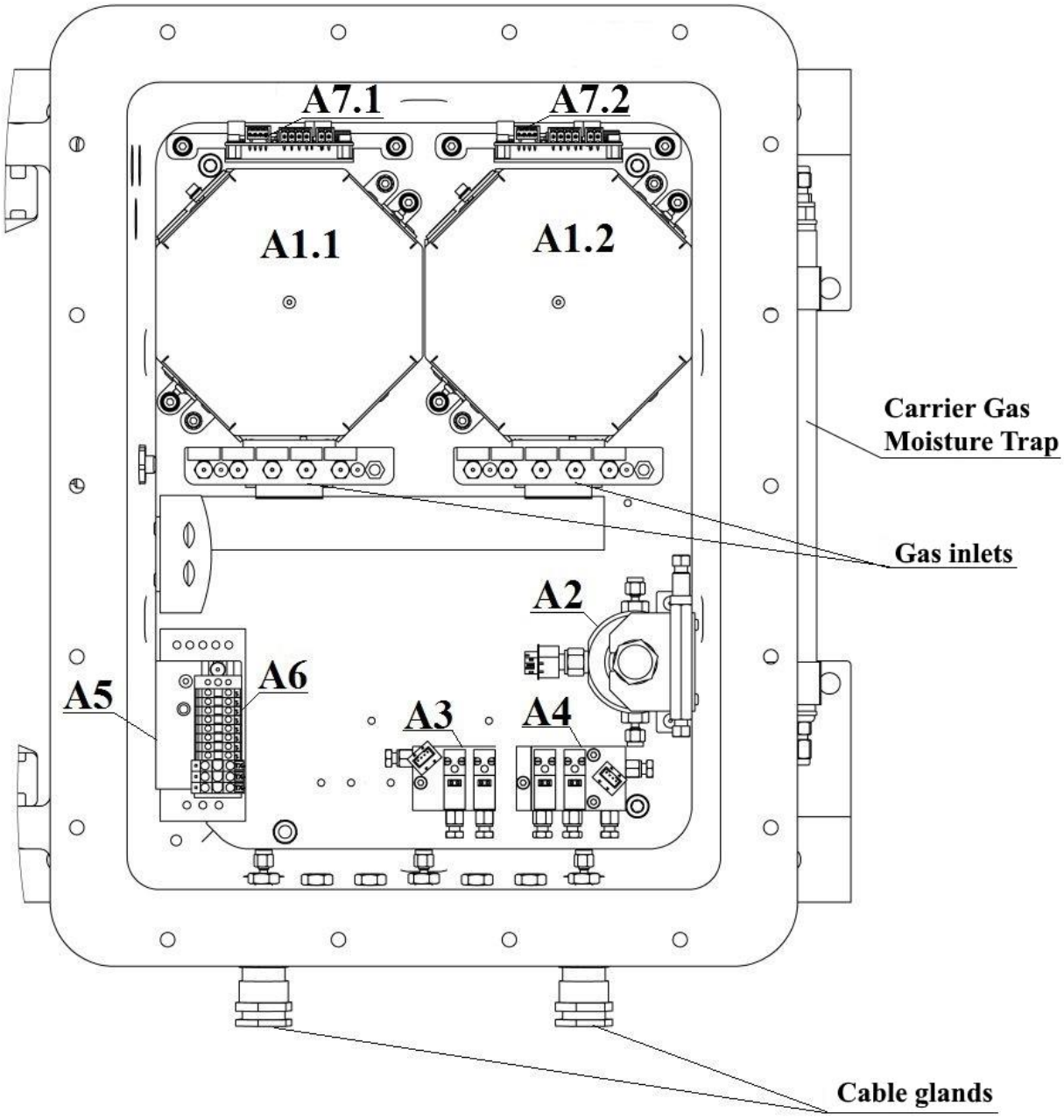


Fig. 4. Internal structure of the chromatograph "MAG" (the cover is not conventionally shown)

The chromatograph "MAG" includes the following functional units (Fig. 4):

- **A1.1, A1.2. Analytical channels**. Each analytical channel is single isothermical thermostatted zone including devices of sample injection and switching of gas flows, chromatograph columns and detectors. Detailed description of the internal structure of the analytical channels is given in point 1.6.1.2.

- **Filter drier of carrier gas (moisture trap)** is installed outside the explosion-proof enclosure (**F1**, see the pneumatic diagram in Fig. 11). It is designed for removal of moisture traces from carrier gas before its supply to the chromatograph.
- **A2. Pressure regulating unit of carrier gas** includes the pressure regulator (**RD**) designed for maintenance of constant pressure of carrier gas at the inlet to the analytical channels (and flow rate at the outlets from them). This unit also includes a pressure sensor of carrier gas **R3** (after the pressure regulator) and an additional filter of carrier gas **F2** (see the pneumatic diagram of the chromatograph in Fig. 11).
- **A3. Stream selector** is a manifold with solenoid valves designed for automatic control of gas flows. Valves **V1** and **V2** are designed for supply of analyzed and calibration gas to the analytical channels. Optionality, the number of valves for supply of the sample can be increased to 6 that will allow to, for example, conduct alternate analysis of 5 gas flows and graduation with one test gas mixture cylinder on one chromatograph. The stream selector can also be equipped with a pressure sensor of analyzed gas **P1** (see the pneumatic diagram of the chromatograph in Fig. 11).
- **A4. Pneumatic control unit** includes solenoid valves **V5** and **V6** designed for switching the pneumatically actuated diaphragm valves **DV1** and **DV2** placed in the thermostats of the analytical channels. The pneumatic control unit also includes a pressure sensor (**P2**) measuring pressure of carrier gas (actuation gas) at the inlet to the chromatograph and designed for emergency alarm in case the pressure of the carrier gas decreases below a set value. In case of such an emergency, heating of sensitive elements of the detectors is switched off to prevent its breakdown when the flow of carrier gas is absent. Optionally, a pressure relay (**PR**) can be used instead of the pressure sensor **P2** to form an emergency signal on pressure of carrier gas.
- **A5. Power supply unit**. It serves for conversion of mains alternating current (with voltage of 220 V) into direct current with voltage of 24 V for power supply of the main components of the electronics module**.**
- **A6. Terminal block** Designed for connection of external electrical circuits to the chromatograph, including power supply and communication.
- **Heated gas inlets.** The heated flame arresters are installed optionally (not shown in Fig. 4) if it is necessary to maintain set temperature of the gas inlets, for example, to prevent condensation of the sample components especially when operating the chromatograph at low ambient temperatures.
- **Electronics module**. It consists of several electronic boards placed inside the housing and on the cover of the explosion-proof enclosure of the device (see below).

If the chromatograph is equipped with the electrochemical detector (ECD), it is placed outside the analytical channel in a separate thermostatted zone, **A1.2**, Fig. 5.

To maintain a required level of humidity in the ECD, a container with water designed for humidification of the carrier gas flowing to blow into the detector is set into the chromatograph.

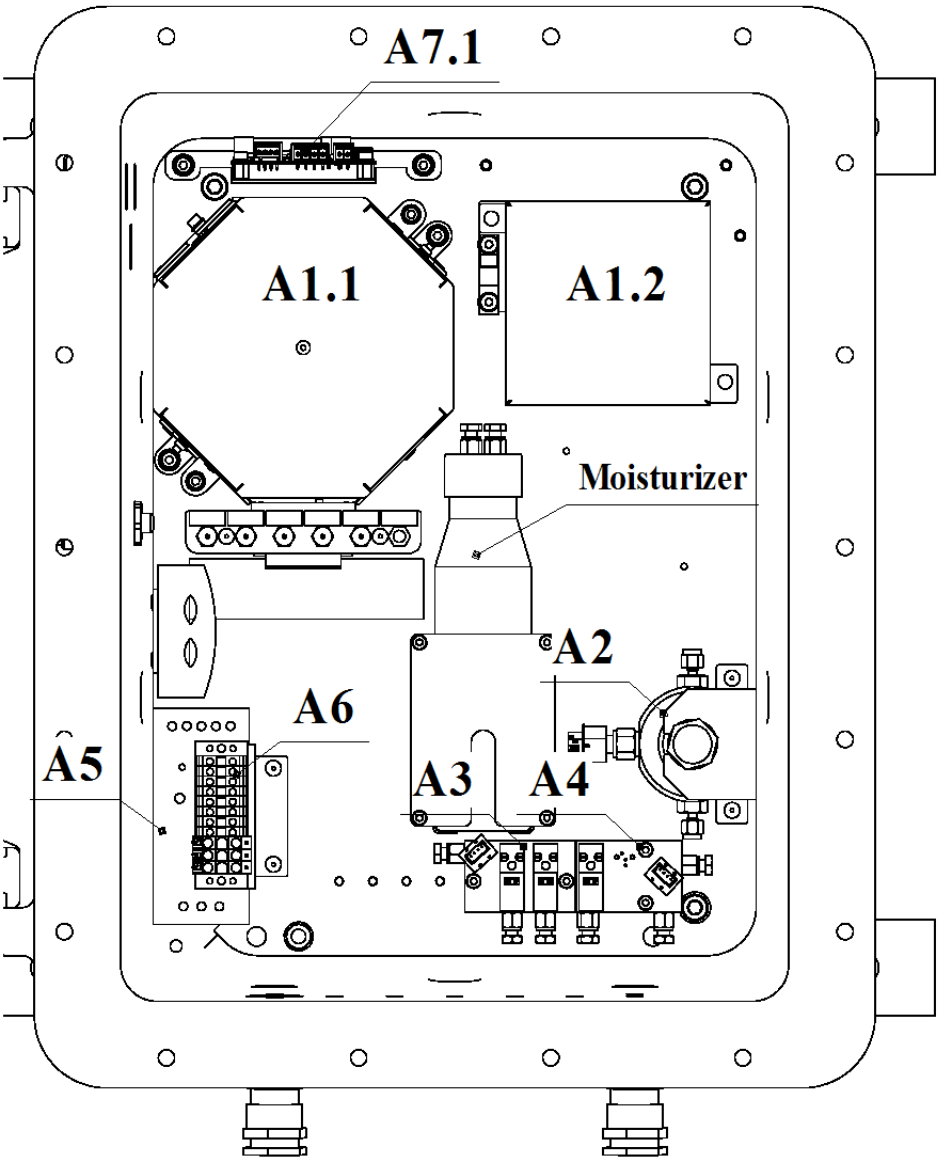


Fig. 5. Internal structure of the chromatograph "MAG" with ECD

1.6.1.1. Description of the electronic units

The electronic units of the chromatograph control are placed in the housing (see Fig. 6) and on the cover (see Fig. 7) of the explosion-proof enclosure of the device.

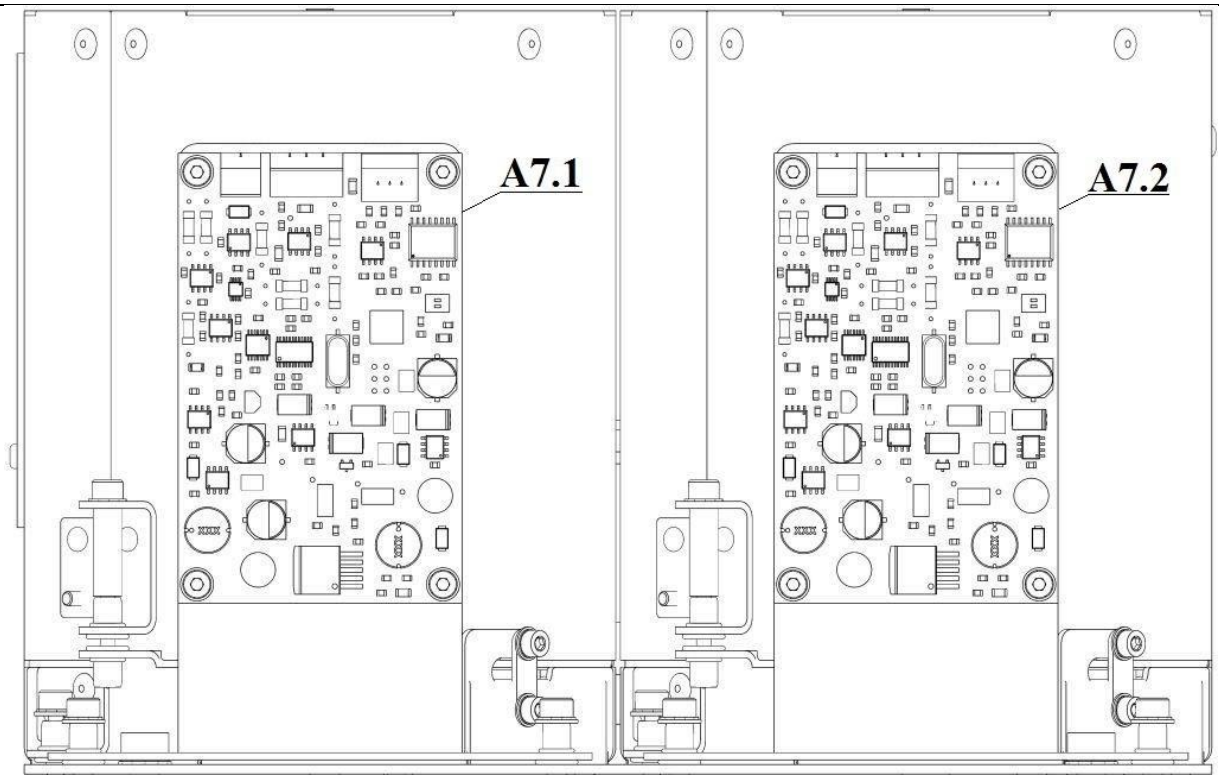


Fig. 6. Electronic modules inside the housing of the chromatograph "MAG"

The following components are placed in the housing of the chromatograph "MAG" on the walls of the analytical channels:

- **A7.1**, **A7.2.** Detector control boards (see also Fig. 4 and Fig. 5). The number of boards of this type is determined by the number of detectors used in the chromatograph.

The following boards are placed on the cover of the chromatograph "MAG" (see Fig. 7):

- **A8.** Motherboard with a microprocessing module and a module of non-volatile memory designed for collection, processing, storage and transfer of measurement results and parameters of the device to external devices as well as control of operating modes of the chromatograph in the automatic mode in accordance with a set algorithm;
- **A9.** Board of heating control with two channels of temperature maintenance. Depending on the number of thermostatted zones, several boards of this type can be installed.
- **A10**. Protection board designed for emergency power off of the device, if maximum permissible values of temperature and pressure in the explosion-proof enclosure are exceeded;
- **A11.** Indication board designed for control of LEDs and LCD display;
- **A12.** Board of sensor display controller(optionally);
- **A13.** Touchscreen (optionally, not shown in Fig. 7);
- **A14.** 12 ”LCD display for display of current information on the state of the device, measurement results and chromatograms, more detailed see point 2.6.4 (optionally, not shown in Fig. 7);

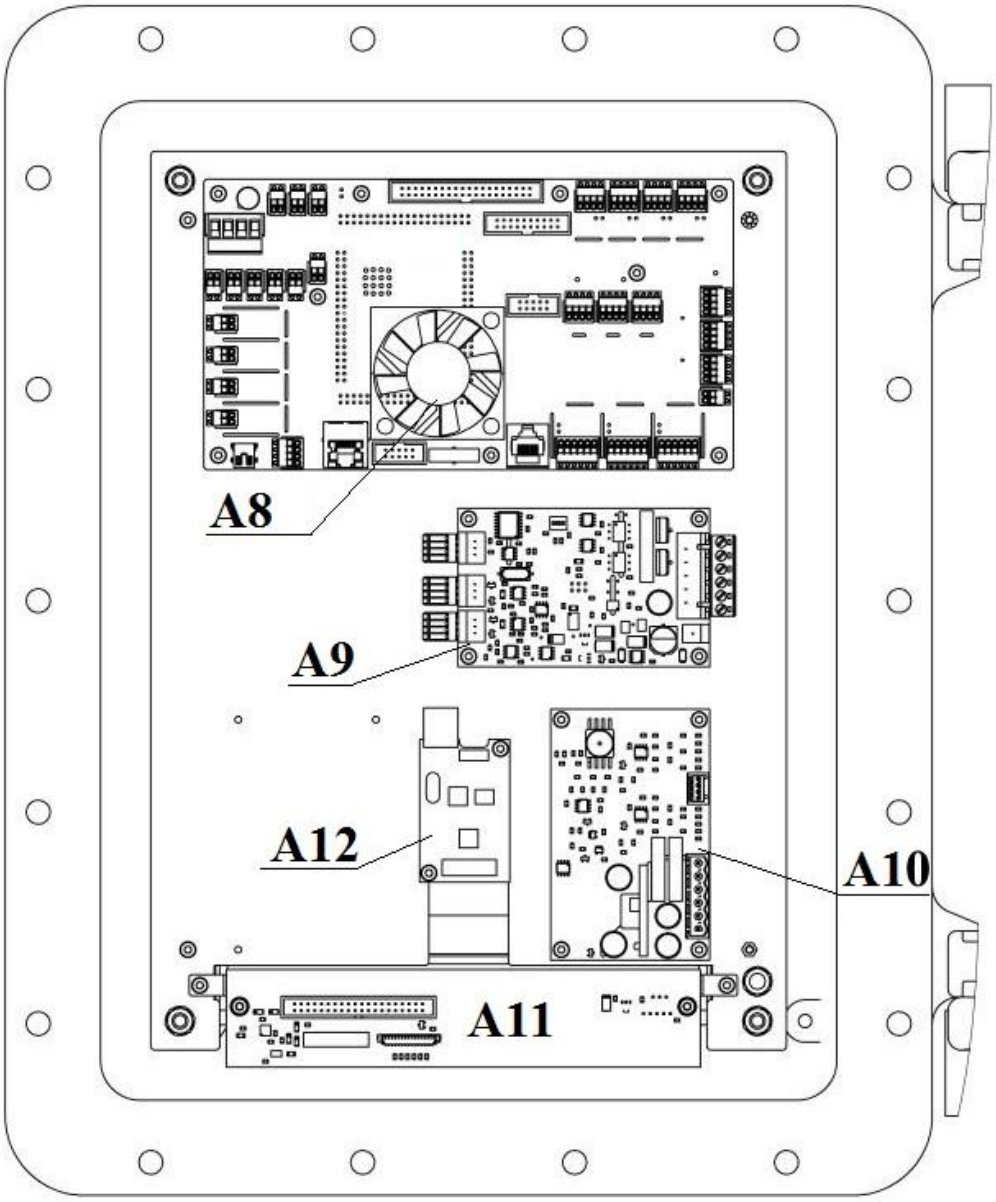


Fig. 7. Electronic modules on the cover of the chromatograph "MAG"

All connectors necessary for connection of the power supply source and communication interfaces are brought in to the terminal block (**A6**), placement of the connectors on which is given in Fig. 17 and in the Appendix A.

1.6.1.2. Description of the analytical channels of the chromatograph

The chromatograph "MAG" can include up to 4 analytical channels. Each analytical channel consists of a thermal conductivity detector or a catalytic combustion detector, a system of chromatograph columns and a multi-port membranous diaphragm valve. The analytical channels are independently thermostatted zones.

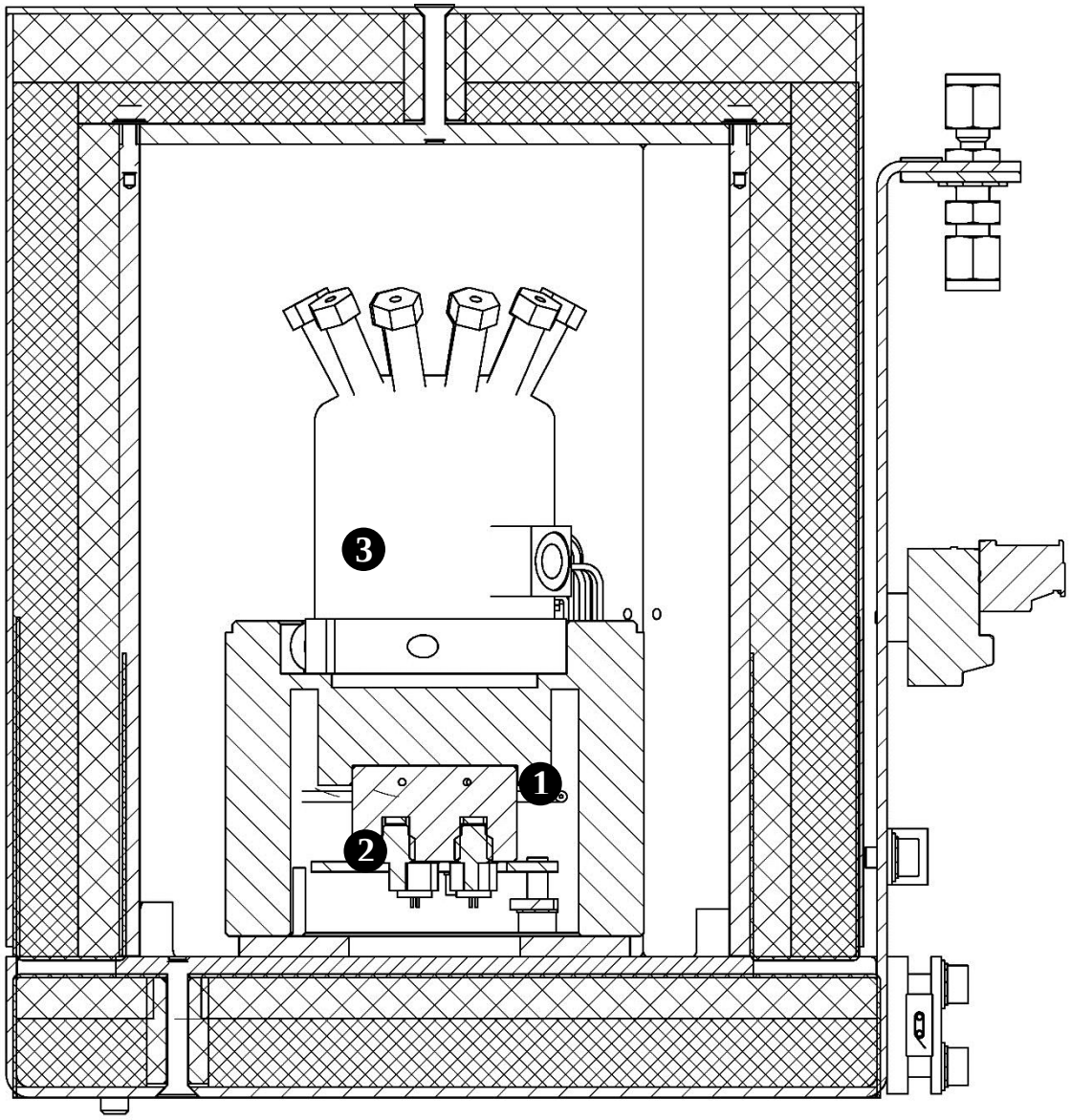


Fig. 8. Analytical channel of the chromatograph "MAG"

The analytical channel of the chromatograph includes a cylindrical aluminum coil (1, see Fig. 8) with heaters and a temperature sensor for maintenance of set temperature of the thermostat. Chromatograph columns are wound on the cylindrical housing of the coil.

Inside the coil there is a thermal conductivity detector, TCD or a catalytic combustion detector, CCD (2) with small internal volume designed for detection of the sample components coming out from the chromatograph column (more detailed about the operating principle of the TCD see p. 1.5.2, CCD – point 1.5.4). In chromatograph modifications with the electrochemical detector, it is placed outside the analytical channel in a separate heated zone (see Fig. 5). At the same time, the analytical channel includes only the column system and the diaphragm valve.

In the upper part of the coil there is a membranous pneumatically controlled diaphragm valve (**DV1** or **DV2**, see Fig. 11) designed for injection of the sample of set volume into the chromatograph

columns and switching of the column system into the position of backflush, during which a part of the sample components is blown from the pre-column in the form of unseparated peak onto the detector. This is used for determination of total content of components with large retention times of, for example, hydrocarbons C_{6+}. The diaphragm valve includes a sample loop with volume of 5–1000 μl.

1.6.1.3. Description of electrochemical detector

The structure of electrochemical detector is shown in the figure below (thermostat cover is not shown for clarity).

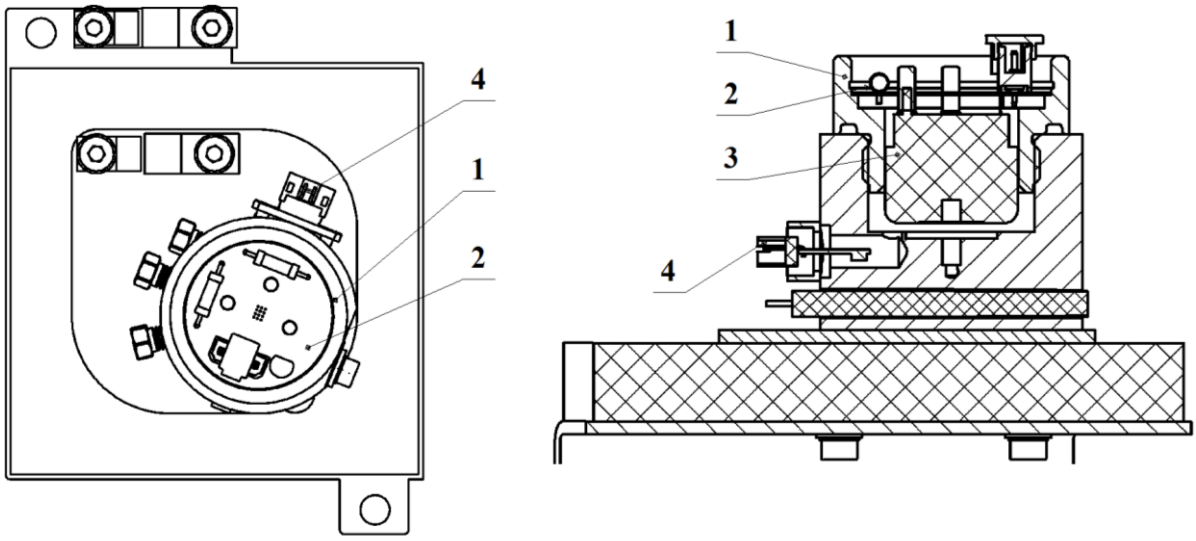


Fig. 9. Structure of electrochemical detector of the chromatograph MAG

The body of the electrochemical detector, shown in Fig. 9 is located in the heated zone; the heater and the temperature sensor are located in the ECD housing. Temperature of the ECD should not exceed 50 °C.

The cover (1), to which the ECD signal preamplifier board (2) is attached, is screwed in by hand into the electrochemical detector housing. The electrochemical sensor (3) is connected to this board.

The electrochemical sensor needs periodic replacement. Service life of the sensor is 2 years, either until the sensitivity decreases below the minimum acceptable level in accordance with the requirements of the measurement procedure. ECD sensor replacement procedure is described in point 3.3.3.2.

To monitor the humidity level of the carrier gas entering the ECD, a humidity sensor (4) is installed into the detector housing. If the carrier gas humidity is lower than 10%, check the water level in the dumper container and, if necessary, fill it with distilled water. The container filling procedure is described in point 3.3.3.3.

1.6.2. TYPES OF USED CHROMATOGRAPH COLUMNS

The chromatograph "MAG" may be equipped with packed, micropacked or open-tubular columns and their combinations. Depending on a solved application, chromatograph columns are filled with different adsorbents or carriers with stationary phases applied on them. The list of the most often used chromatograph columns with specified fields of their application is shown in the table below.

Table 5. Types of columns of the chromatograph "MAG"

Adsorbent / stationary phase	**Analyzed substances**
Molecular sieves (CaA, NaX)	Permanent gases, including separation of N_2 and O_2
Carbon molecular sieves (Carbosieve)	He, H_2, air without separation, CO, CH_4, CO_2
Porous polymeric adsorbents (Porapak, Hayesep D, Q, R, S, N, A, T), including in open-tubular PLOT columns	Air, CO, CO_2, hydrocarbons C1–C4, including unsaturated hydrocarbons, H_2O, H_2S, SO_2, NH_3, amines, light alcohols, aldehydes, ketones, etc. volatile organic compounds.
Silica gel (silochrome, ResSil in pure form and with different stationary phases)	Hydrocarbons C1–C6, including unsaturated hydrocarbons (ethylene, acetylene, propylene, propadiene, methylacetylene, butylenes)
Aluminum oxide (Al_2O_3-KCl, Al_2O_3-Na_2SO_4, open-tubular columns with Al_2O_3)	Hydrocarbons C1–C5, including unsaturated hydrocarbons (ethylene, acetylene, propylene, propadiene, methylacetylene, butylenes)
Non-polar stationary liquid phases on diatomite supports (E301, SE30, squalane, apiezon L on Chromosorb P NAW, etc.), or open-tubular columns with polysiloxane liquid phases (MXT-1, MXT-5, MXT-1701, etc. or analogues)	Aliphatic hydrocarbons C1–C10, aromatic hydrocarbons, alcohols, ethers, fatty acids, glycols, halogen-containing hydrocarbons, ketones, H_2S and mercaptans (on open-tubular column with electrochemical detector)
Non-polar stationary liquid phases (polyethylene glycol, TCEP, esters on diatomite, carbonic and teflon supports)	Alcohols, aldehydes, ketones, ethers, fatty acids, glycols, aromatic compounds, unsaturated hydrocarbons, halogen-containing hydrocarbons, nitrocompounds and other polar volatile organic compounds

The above list is by no means comprehensive, the choice of chromatograph columns for a specific application is performed by the manufacturer’s specialists in accordance with requirements of the customer’s questionnaire.

1.6.3. STRUCTURE AND OPERATION OF THE INECTOR-VAPORIZER

The chromatograph "MAG" can be equipped with an injector-vaporizer for dosing liquid samples and liquefied gases.

1.6.3.1. Technical specifications and application of the vaporizer

Technical specifications of the vaporizer:

- Maximum pressure of the liquid sample, MPa: 7
- Maximum operating temperature of the vaporizer, °C: 180
- Volume of the injected sample, μl 0.2–0.3

The vaporizer allows to inject the liquid sample flowing through it under operating pressure directly into the analytical channel of the chromatograph with simultaneous vapor of the injected sample. Maximum boiling temperature of the sample is approximately 150 °C and may vary depending on an application and conditions of conduct of measurements. When dosing liquefied gases, it is necessary for the sample to be homogeneous with operating pressure at the inlet into the vaporizer, i.e without partial preliminary gas liberation of the sample.

1.6.3.2. Placement and structure of the vaporizer

The vaporizer consists of the following elements (see Fig. 10):

- Evaporation zone — heated area of the vaporizer, in which dosed volume of the sample evaporates.
- Sampling area — unheated area of the vaporizer with inlet and outlet fittings, through which the analyzed liquid sample flows.
- Dosing rod with a flowing riffle flown about with the sample, moving when the sample is injected into the evaporation zone.
- Pneumatic cylinder serving for switching the rod into the sampling position or the position of probe dosing.

The vaporizer is mounted on the side of the explosion-proof enclosure of the chromatograph so that the heated area is inside the chromatograph housing and enters directly into the analytical channel (thermostat) of the device.

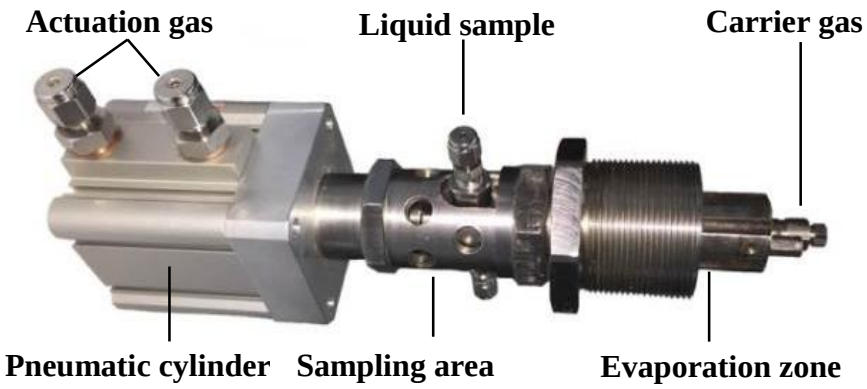


Fig. 10. Injector-vaporizer for the chromatograph "MAG"

1.6.3.3. Operating principle of the vaporizer

Operating cycle of the vaporizer consists of two stages: sampling and injection of the sample.

During sampling, the liquid sample under operating pressure flows through inlet and outlet fittings of the vaporizer, placed in the sampling area (see Fig. 10), at the same time flowing about the flowing riffle of set volume on the dosing rod. This area is not heated and thermally isolated from the evaporation zone to avoid preliminary partial vapor of the sample flowing through the vaporizer. Carrier gas at the same time blows the evaporation zone and is supplied to the inlet of the chromatograph column.

When dosing the sample, actuation gas is supplied to one of the rods of the pneumatic cylinders, at the same time the dosing rod moves to the heated area in which volume of the sample is evaporated, placed in the flowing riffle of the rod and the evaporated sample is supplied to the inlet of the chromatograph column with the flow of carrier gas.

After some time, actuation gas is supplied to the other fitting of the pneumatic cylinder and the dosing rod returns to the sampling position.

1.6.4. OPERATING THE CHROMATOGRAPH MAG

The example of the MAG chromatograph pneumatic diagram in the configuration with two analytical channels, thermal conductivity detectors in the version for 2 analyzed flows (including calibration gas) is shown in Fig. 11. The current pneumatic diagram for the specific chromatograph version is given in the Appendix A.

Sample components simultaneously separate and determine in two analytical channels at the specified chromatography configuration. The configuration and operating mode of the application are determined by the application characteristics and are described in detail in the Appendix A to the Operation manual for each specific version of the MAG chromatograph.

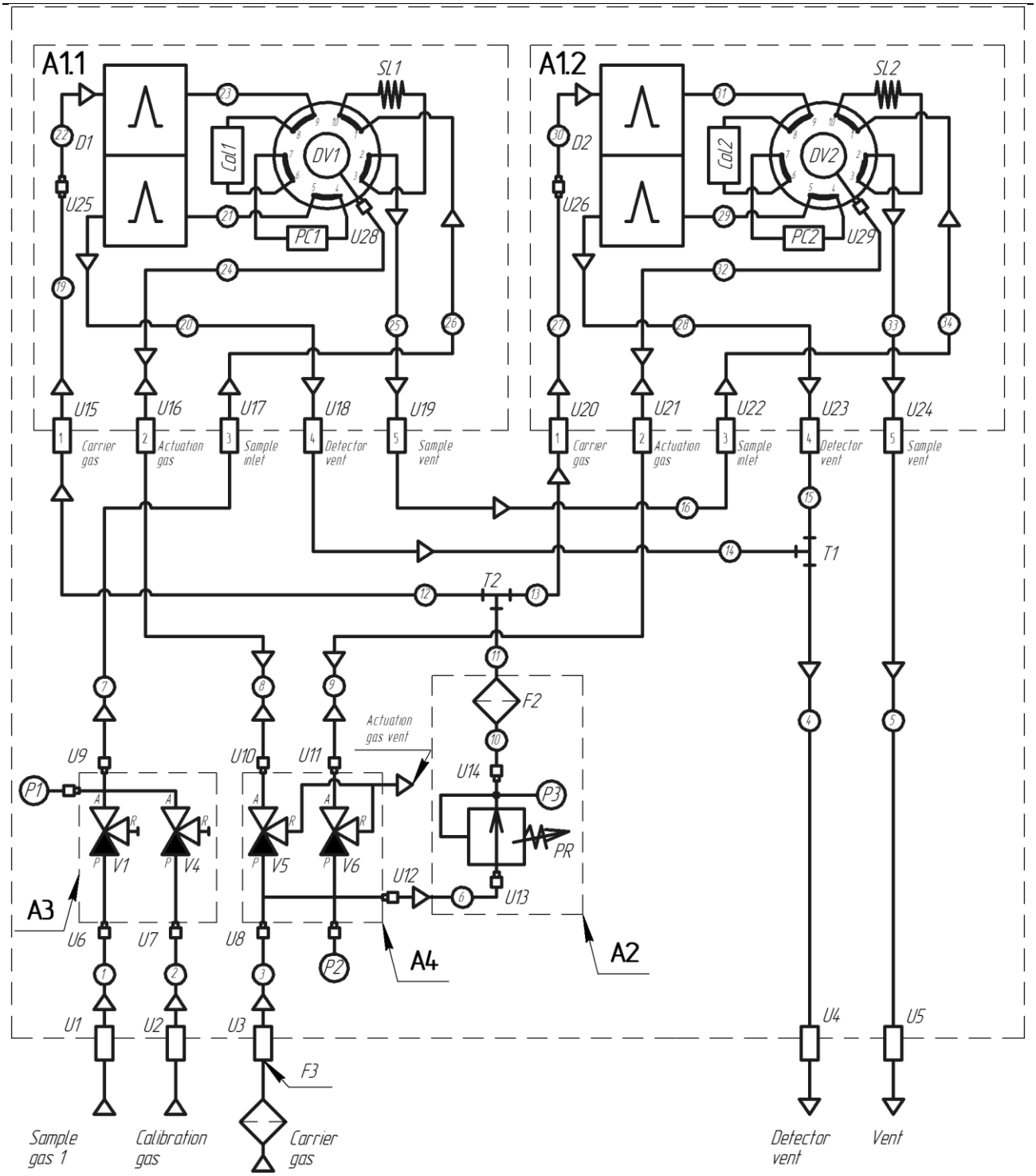


Fig. 11. Chromatograph MAG pneumatic diagram with two TCDs

Fig. 11 shows the MAG chromatograph pneumatic diagram on standby when all **V1, V2, V5, V6** solenoid valves are in the off state; *A* and *R* solenoid valve ports are connected, the *P* port is closed. When the solenoid valve is on, its *A* and *P* ports are connected, the *R* port is closed.

Detailed description of the analytical cycle stages using the example of this pneumatic diagram is given below.

1.6.4.1. Sampling mode.

In the sampling mode, the **V1** valve is on at the **A3** stream selector. In this case, the sampled gas flows to the **V1** solenoid valve, then to the **DV1** diaphragm valve, where it passes through the **SL1** sample loop and then goes to the **DV2** diaphragm valve, where it passes through the **SL2** sample loop. Then the sample is discharged.

Carrier gas passing through the **F1** filter drier, the **F3** mechanical impurity filter, the **A4** pneumatic control unit and the **A2** pressure regulating unit is supplied at a predetermined pressure to the comparison cells of the detectors **D1** and **D2**, then purges the **Col1** and **PC1** chromatographic columns and precolumns in the first analytical channel and **PC2** and **Col2** in the second channel and through the sample cells of the **D1** and **D2** detectors, is discharged.

1.6.4.2. Sample pressure equalization

In this mode, the diaphragm valve position remains unaffected. The **V1** stream selector valve closes blocking the sampled gas flow as a result of which the pressure in the **SL1** and **SL2** sample loops is reduced to atmospheric to provide reproducibility of the sample volume regardless of possible pressure fluctuations of the sampled gas.

1.6.4.3. Sample injection

In this mode, the **V5** and **V6** valves are on, they supply the carrier gas that is as an actuation gas to the **DV1** and **DV2** cranes, respectively, resulting in their position switching. In this case, the carrier gas blows the **SL1** and **SL2** sample loops that allows the sample injection from them into the chromatographic columns, first, the sample with the carrier gas flows to the **PC1** and **PC2** precolumns where the components are pre-separated, and then fed to the **Col1** and **Col2** main separation columns.

1.6.4.4. Backflush

After a certain time selected for the given column system, the **V5** and **V6** valves are switched off, the actuation gas is discharged to atmosphere, and the **DV1** and **DV2** the initial position shown in Fig. 11. In this case, the sample components that do not have time to pass through the **PC1** and **PC2** pre-columns are blown with the carrier gas in the opposite direction and in the form of total peaks fall at the sample cells of the detectors **D1** and **D2**.

It is also possible to configure the analytical channels of the chromatograph when the backflush is discharged. This is used if the backflush peak is not measurable and prevents peak counting of the analyzed sample component.

The remaining components that are managed to get into the main **Col1** and **Col2** separation columns, continue to move along them in the carrier gas flow leaving as separate peaks on the **D1** and **D2** detectors.

The analysis cycle time depends on the application and is, as a rule, no more than 10 minutes when using narrow-borrow columns. In particular, the determining cycle of the flammable natural gas compositional analysis is no more than 6 minutes.

1.6.4.5. Features of the MAG chromatograph operating with ECD

The example of the MAG chromatograph pneumatic diagram with an electrochemical detector is shown in Fig. 12. The feature of this diagram is that the ECD unit (**A1.2**) is removed out of the main analytical block (**A1.1**) and is located in a separate heated zone.

In addition, when using ECD, a moisturizer is mounted in the equipment to provide the required humidity level in the ECD. Part of the carrier gas that passes through the **T1** T-joint and the flow restrictor **11**, purges through the moisturizer, becomes saturated with water vapor, and then is fed to the ECD as a make-up gas mixing with the carrier gas that comes out of the chromatographic column. Carrier gas bypass ratio through the column and the moisturizer is approximately 3:1, it is achieved by selecting flow restrictor **11**. The carrier gas humidity is controlled by a **HS** humidity sensor installed in the ECD housing at the carrier gas discharging.

Air is used as a carrier gas when ECD using. Filter-driers using for the carrier gas in this case is not required.

When analyzing low concentrations of sulfur compounds with the ECD, all parts of the gas path that are in contact with the analyzed sample are made of inert materials that do not adsorb and react with the sulfur compounds.

All stages of the analytical cycle using ECD coincide with those described above.

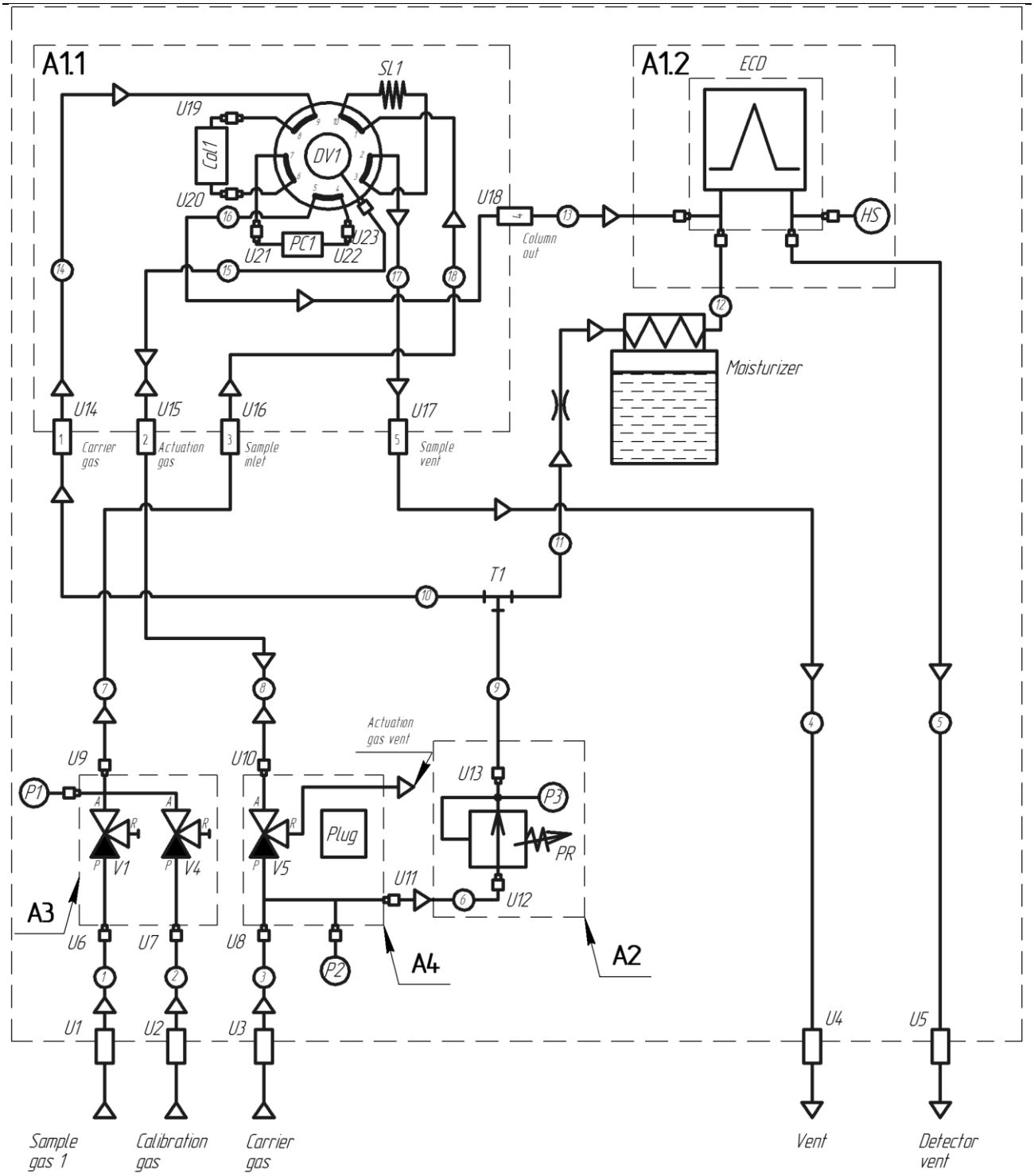


Fig. 12. Chromatograph MAG pneumatic diagram with ECD

1.6.4.6. Features of the chromatograph MAG operating with the injector-evaporator

The example of the chromatograph MAG pneumatic diagram with an injector-evaporator is shown in Fig. 13. This circuit characteristic is that the injector-evaporator is located outside the chromatograph explosion-proof housing that passes through its wall and enters directly into the analytical channel to minimize heat loss and to prevent component condensation of the evaporated sample.

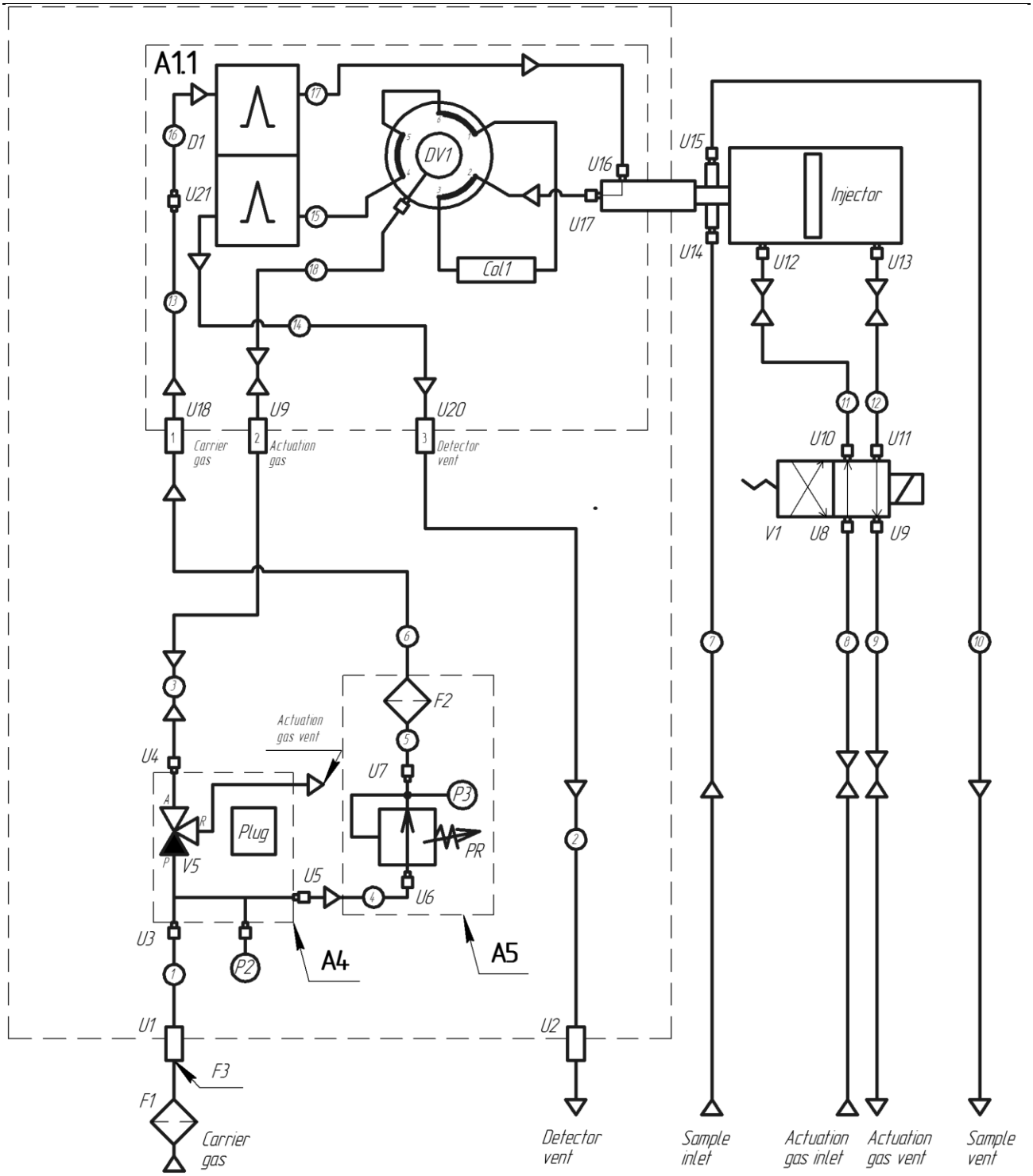


Fig. 13. Chromatograph MAG pneumatic diagram with the injector-evaporator

The liquid sample flowing through the injector is injected by the actuation gas feeding into the injector pneumatic cylinder with the **V1** external explosion-proof solenoid valve. And the injector rod with a fixed volume of the liquid sample moves to the heated zone, the sample evaporates and is introduced into the **Col1** chromatography column with the carrier gas flow. A few seconds when sample injecting, the **V1** valve switches initially and the injector returns to the "select" position. Further, if necessary, the **DV1** valve can be switched by actuation gas supplying with the **V5** valve for the purpose of the backflush.

When analyzing liquefied gases using the injector-evaporator, the regulated flow restrictor is set at the discharge of the sample by means of which the working pressure of the sample is provided in the injector to avoid its early degassing.

1.7. DEVICES FOR INDICATION OF PARAMETERS AND OPERATING MODES OF THE CHROMATOGRAPH MAG

The chromatograph has the following indication elements and controls:

- A LED array at the front of the chromatograph (when the chromatograph is equipped with an LCD display and a touchscreen, Fig. 14) that is designed to visualize the main modes, display errors and accidents of the chromatograph. The purpose and functions of the LEDs are shown in the table below.

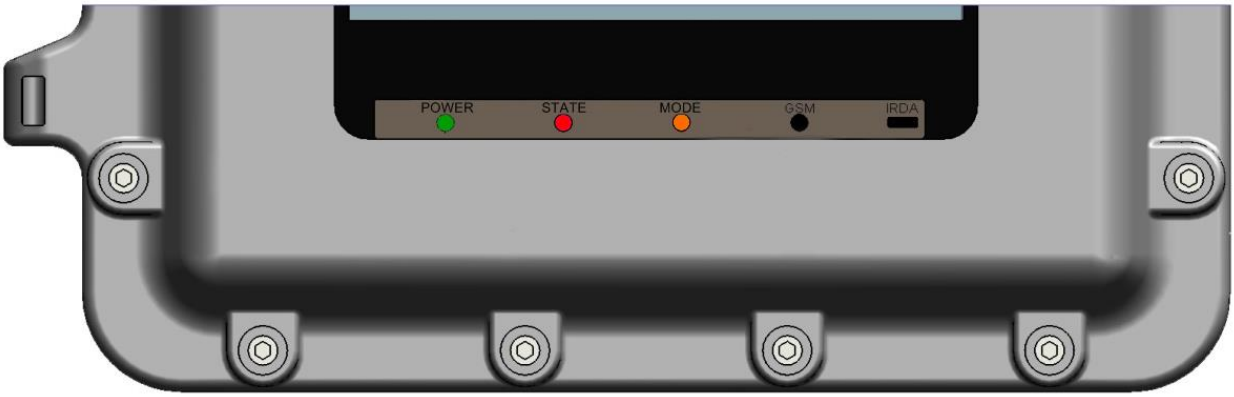


Fig. 14. Appearance of the LED panel

Table 6. Purpose and functions of the indicator panel LEDs

LED Name	Color	Functions and purpose
Power	Green	The device is powered by the electric power supply (+24V).
	Off	No power
State	Green	Ready. The system operates properly, parameters of the analytical channels comply with the set values.
	Orange	Not ready. The parameters of the analytical channels do not correspond to the specified values. The equipment is heated if the relative mode is started. As a rule, manual intervention is not required.
	Red	System error. It occurs in the event of a fault by pressure of the carrier gas, and also in the event of an error in one of the electronic modules of the device (loss of connection between boards, overheating of detector wires, etc.). Typically, operator intervention is required for problem solving.
Mode	Green	Analysis (including graduation or verification)
	Off	The device is stopped
	Orange	Waiting. Pause between analyses or the device reaches the mode
GSM	Green	Data transmission through the GSM channel
	Off	GSM is not connected or does not operate

- LCD display (optional) is meant for chromatograph conditions rendering, detailed information displaying and interactive control panel implementing;
- touchscreen (optional, when the chromatograph is equipped with the LCD display) between the window of the explosion-proof box and the LCD display is intended to manual device control, information input, scheduled operation;
- remote workplace with the pre-installed "Analyzer.Network" service software.

1.8. MARKING

1.8.1. On the plate installed at the chromatograph (Fig. 15), the following should be indicated:

- manufacturer's trademark;
- product name;
- serial number;
- production year;
- approval sign of the measuring device type according to PR 50.2.009;
- electrical parameters of the chromatograph;
- maximum permissible gas pressure in gas lines;
- permissible range of ambient temperature at the place of the product mounting;
- symbol of explosion-proof equipment (Ex);
- explosion-proof marking and protection against external influences;
- CB (certification body) abbreviation and certificate number;
- conformity mark as per GOST R 50460-92;
- manufacturer name and address.

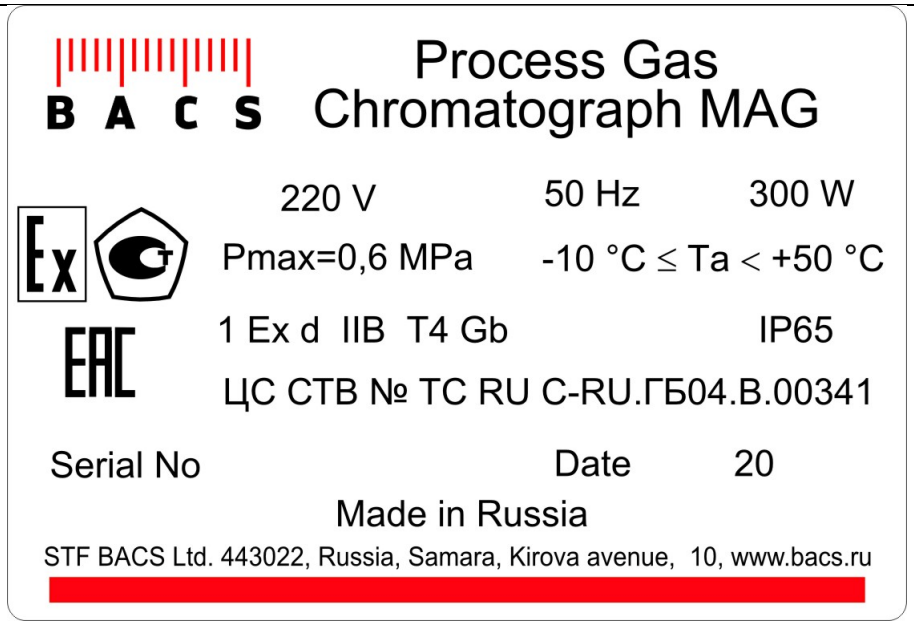


Fig. 15. Chromatograph MAG marking plate

The design of the marking plate is selected depending on the chromatograph explosion protection type.

1.8.2. There is a warning label at the cover of the chromatograph:

Open after 30 minutes since power-off

1.9. PACKAGING

Chromatograph packaging is made in accordance with its operating documentation. Chromatograph should be packed in a wooden or plywood case. Before cased, the chromatograph shall be placed in a plastic bag to prevent moisture ingress on it (or other material that does not allow moisture).

Chromatograph is placed in a shipping container and fixed to exclude movement.

The shipping container (package) also contains the operating manual, its certificate, verification procedure and certificates that are packed in a separate plastic bag.

A packing list with the following information should be put in each box of the shipping container:

- name and designation of the chromatograph, completeness of set;
- packing date;
- signature or stamp of the person responsible for packaging and QCD stamp.

The packaging list should be enclosed in a plastic bag and be under the case lid at the top layer of the packaging material so that its safety is ensured.

The shipping container shall be sealed by the manufacturer's QCD.

2. INTENDED USAGE

2.1. GENERAL OPERATION

2.1.1. Chromatograph is a complex device that combines elements of electrical test equipment, gas flow control systems and pneumatic control components.

2.1.2. While in operation, it is necessary to watch out for the work of the chromatograph. After any change in work, it is necessary to check up pressure of gas carrier and sampled gas, tightness of gas lines and to look through chromatograph event log.

It is necessary to monitor at least 1 time per day:

- on-site ambient air temperature;
- bottle pressure of the gas carrier (when the pressure drops below 0.4 MPa, the device is switched off);
- bottle pressure with a calibration mixture (when the pressure drops below 0.1 MPa, the device stops gas analysis);
- flow line pressure of sampled gas (when the pressure drops below 0.03 MPa, the device stops gas analysis). Pressure difference in the operating line of sampled gases should not differ by more than 20-25%.

If the flow pressure in calibration gas line and gas-carrier is lower than the minimum allowed, it is necessary to replace the corresponding cylinder. If there is a difference in pressures in the operating lines of sampled gases more than 25%, it is necessary to adjust the pressure values with the help of appropriate gear sets in the sample preparation unit.

The device can be equipped with external pressure sensors of carrier gas and calibration gas, allowing to monitor pressure in cylinders with these gases remotely and conduct their replacement.

2.2. SAFETY PRECAUTIOUS

WARNING!

Only qualified personnel with special training can be admitted for maintenance and operation of the chromatograph.

Pipelines and cylinders operating under the pressure-operated compressed gases (up to 15 MPa) are used by the chromatograph. Therefore, it is necessary to observe the safety rules provided, when operated at devices under excessive pressure.

2.2.1. There are electrical circuits at 220 V. Therefore, when installing the chromatograph in an explosive atmosphere, it is strictly necessary to follow the instructions of the following documents:

- "Installation instruction for equipment of power and lighting networks in explosive zones VSN-332-74";
- "Rules for installing electrical facilities" (PUE);
- "Life Saving Rules (PTB)";
- "Rules for the technical operation of electrical installations (PTE)", including ch. ESh-13;
- "Electrical equipment of explosive productions";
- "Application rules for technical devices at hazardous production facilities";
- "General rules of industrial safety for organizations operating in the field of industrial safety of hazardous production facilities" PB 03-517-02;
- "Inter-industry labor safety rules for the operation of electric installation" POT RM-016-2001.

2.2.2. According to the method of protection of a man from electrical shock the chromatograph corresponds to the class I of GOST 12.2.007.0 SSBT

2.2.3. Jumpers and wires connection to the chromatograph should be performed only after the de-energization of the unit.

2.2.4. To ensure safety requirements during operation, the chromatograph must be grounded.

2.2.5. The connection and disconnection of the chromatograph from the main line, feeding target medium, must be done after closing the valve on the line before the chromatograph.

2.3. DISPOSAL AND ASSAMBLY

2.3.1. The chromatograph shall be placed on site according to this instruction.

2.3.2. Installation connections:

- carrier gas lines;

- sampled gas lines;
- standard calibration mixture lines;
- discharge of sampled products and carrier gas lines;
- power utilities, connecting the device with external devices.
- power supply.

2.3.3. The gas line connection is by a tube with an external diameter of 3mm (or 1/8") and an internal diameter of 2mm.

Refer to dimensional drawing to fix the chromatograph to the wall or frame (Fig. 3).

2.3.4. The chromatograph should be provided with free access from three sides.

2.3.5. On-site permissible temperature is from -10 to 50°C at a relative humidity not more than 95%.

2.3.6. The minimum allowed distance between the device and the radiant is 0.5 m. The minimum allowed distance between the device and the radiant is 0.5 m.

2.4. INASALLATION ORDER, PRE-STARTING PROCEDURE, STARTUP

2.4.1. On-site installation of the chromatograph. Installation should be carried out according to the instructions given in Sections 2.3, 2.4 of this Operating Manual.

2.4.2. Chromatograph should be located as close as possible to the sampling point, as this reduces the transportation lag time and facilitates the transportation of the sampled product.

2.4.3. Examination of explosion suppressant. The inspection is carried out by external examination. On the surfaces of parts that provide explosion protection, slaughter, scratches, dents, damage to coatings, damage to threads are not allowed. Items with defects must be rejected and replaced with new ones supplied by the manufacturer. Check the presence of plates and the clarity of the inscriptions, the content and quality of the marking of explosion protection and its compliance with the current certificate.

2.4.4. Preparation for operation and switching on the chromatograph

2.4.4.1. Connection of gas lines of carrier gas, sampled and calibration gases.

The standard gas inlet assignments are shown in Fig. 16, as well as in the Appendix A (by reference to specific features of the chromatograph). Unmarked gas inlets are muffled.

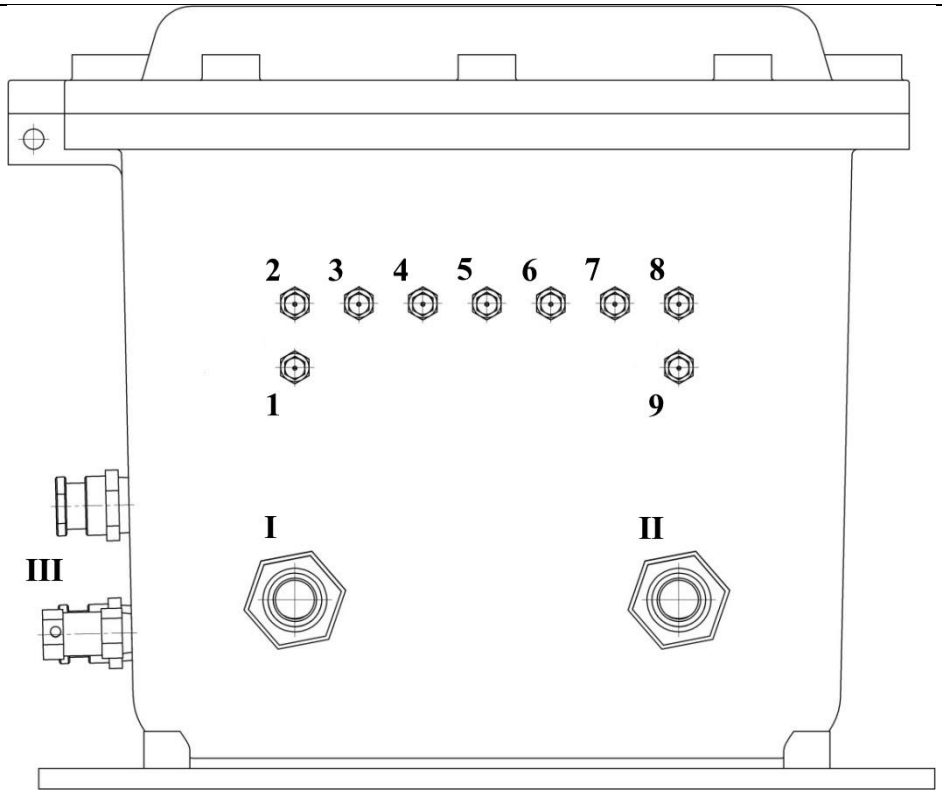


Fig. 16. Use of the gas inputs of the chromatograph "MAG"

Pneumatic connections:

1 – carrier gas inlet;

2-4 – sample gas inlets;

5 – calibration gas inlet;

6, 7 – not used (plugged);

8 – detector vent;

9 – sample vent.

Connection of gas lines to the corresponding terminals of the chromatograph is performed by tubes with an external diameter of 3 mm (or 1/8") and an inner diameter of 2 mm using adapters with a compression fitting included in the scope of delivery.

Sampled gas comes to the chromatograph through the sample preparation unit, which provides the gas parameters (pressure, flow rate, mechanical filtration degree) referred to in point 1.2.1. The sample preparation unit can be supplied complete with a chromatograph on request, or be provided by the customer.

Gas in pressurized cylinders is used as gas carrier. The gas carrier cylinder should be installed in a vertical position in a special place and be securely fixed. Special high-pressure regulator (reducer) shall be placed at the cylinder.

Gas supply characteristics are given in point 1.2.1.

The chromatograph discharge line should be connected to the enterprise discharge lines, with no sudden changes in pressure.

2.4.4.2. Electrical circuit connections to a chromatograph

Electric line connection is carried out with the help of armored cables through the cable entry located on the bottom and side wall of the chromatograph.

Electrical connections (Fig. 16**):**

I – Power supply inlet;

II – Data transmission inlet;

III – Additional inputs/outputs (e.g. external pressure sensors, NAMUR discrete inputs, relay outputs, etc.).

Power and communication cables are connected to the terminal block of the chromatograph **A6**, function is shown on the Fig. 17 (for the standard version), and also in the Appendix A (by reference to specifics of the chromatograph).

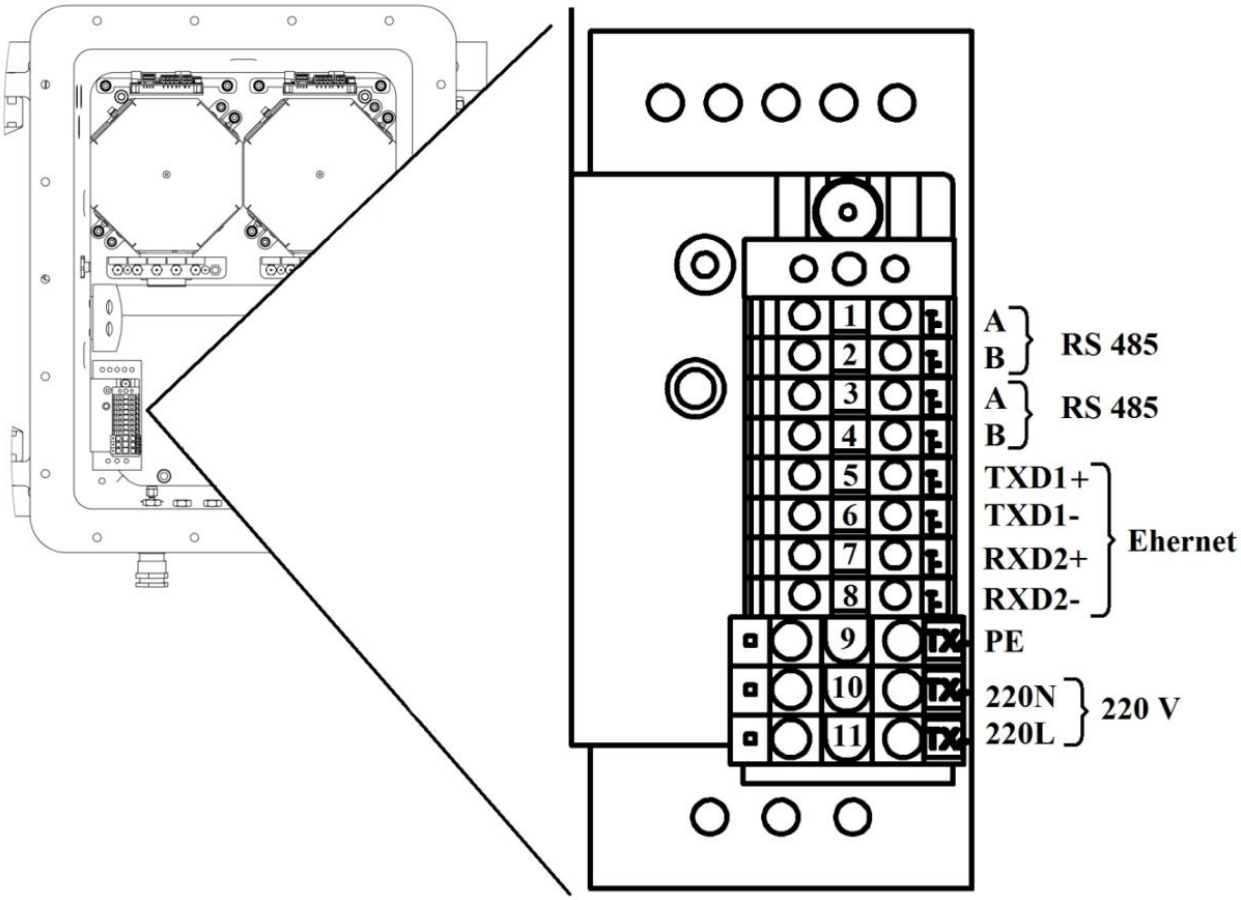


Fig. 17. Function of connectors on the chromatograph terminal block

Electrical supply to the chromatograph is supplied with an armored cable with copper conductors cross-section of 1.5 mm^2. Number of cores in the cable — three.

The data cable is supplied by an armored twisted pair cable with shielding of each pair and a cross section of 0.5 mm^2. The number of twisted pairs in the cable — three.

The chromatograph must be grounded by means of ground terminals to a separate dedicated external ground bus.

2.4.4.3. Run of the service software "Analyzer.Network" on a remote workstation.

Operation sequence of connection to the chromatograph and setting parameters of communication with the device is described in the description of the software (included in the scope of delivery) and in the help section of the Analyzer.Network software.

2.4.4.4. Switching on the chromatograph

Switching on, the "Power" LED on the front panel lights up. If the pressure of the carrier gas, the atmosphere inside the explosion-proof enclosure and the temperature of the device is appropriate to the working ones, a self-test mode starts, lasting 15-20 seconds. Then, if the device was in automatic mode at the moment of powering off, the device prepares for analysis, accompanied by the LEDs glow of the "Status" and "Mode" in orange. If the device was stopped when the power was turned off, the Mode LED will be turned off and it is necessary to start the device manually using the touchscreen interface (see 2.6.4) or using the Analyzer.Network software installed on the remote PC (see Operator's manual of the Analyzer.Network software).

After the device goes into operation mode, the "Status" LED glows green, and the "Mode" LED has a status, depending on the current mode of operation of the device (Table 6). During the self-test, the operating system of the device is loaded, after which the touch panel is activated and an interactive menu appears on the display.

Note In the absence of a display device and a LEDs panel, the current state of the chromatograph can be monitored via remote access using the software Analyzer or Analyzer.Network installed on a personal computer (see the description for the relevant software).

2.5. OPERATION PROCEDURE

2.5.1. Communication setup

The connection with the network is established according to the instruction manual for the “Analyzer” or “Analyzer.Network” software installed on an external computer. These programs are included in the scope of delivery

2.5.2. Instrument setup

For the chromatograph operation checking a cylinder with a sampled or calibration gas is necessary. The first few tests are carried out manually. If necessary, the measurement procedure, the carrier gas pressure, the temperature of the thermostat and the program for automatic control of the chromatograph operation are adjusted and corrected according to the results of the first analyses.

Correction is carried out using the "Analyzer.Network" software included in the scope of delivery and installed on an external computer.

2.5.3. Measuring

The primary function of the chromatograph "MAG" is the gas analysis, liquefied gas and liquids automatically. Enabled, the chromatograph by default enters the automatic mode of operation with the manufacturer's settings. In order to switch to manual mode use the interactive interface of the touchscreen of the chromatograph (if available), or by using the "Analyzer.Network" software according to the software manual.

Before carrying out the measurements, it is necessary to blow the gas lines of the chromatograph. For this purpose, the device is switched to automatic mode and 10-20 preliminary measurements are carried out.

2.5.4. Calibration of the instrument

The chromatograph is calibrated in automatic mode according to the algorithm to customer-specific requirements or the measurement procedure for this type of analysis

2.6. SOFTWARE

2.6.1. DESCRIPTION OF CHROMATOGRAPH “MAG” FIRMWARE.

Chromatograph “MAG” has optional firmware, designed for chromatograph data system. Firmware written in C++ language and functioning in chromatograph on-board PLC environment.

Note: In case of absence of firmware, by agreement with the customer, its functions could be provided by Analyzer software installed on the PC. In that case see description of Analyzer software.

2.6.1.1. Firmware is performing algorithms set within selected method during analysis:

- At 00:00 (or after loading) choosing required daily working pattern;
- Starts on schedule needed sets of command for single time analysis;
- Performs control of analysis execution;
- Performs detachment and identification of peaks according to selected algorithms after finish of capture;
- Performs required values calculation in set consequence and on set expression;
- Saves calculations results in separate analyses while grouping (if needed) several sequential single measurements;
- Performs automatic calibration of chromatograph according to set algorithms during control gas mixture analysis (GMA).

In addition, firmware during its functioning;

- Provides safety and control of metrologically important parts of program and saved data;
- Fixes alterations in firmware settings and Users interference in its operations modes in Interferences log;
- Carries out User interface with touchscreen (if present) which allows to perform:
  - Firmware and its calculation module identification;
  - Review of recent analyses results by flows;
  - Review of archival analyses results by flows;
  - Review of Interferences log events;
  - Start/stop random single or daily mode of capture;
- Provides support of bridging configurational programs which is running under OS Windows series, by closed protocol of exchange using canals RS232/485 or Ethernet;

- Provides by open protocol of exchange Modbus RTU/TCP:
  - Delivery of service and status information about chromatograph condition (pressure in tanks, pneumatic diagram, temperature etc.) into High-Level Computerized Process Control System; results of measurements of present or archival analyses; averaged measurement results for random selection by separate analyses; events of Interferences log for random time interval;
  - Reception of conditional-constant values of applying substances concentrations level from High-Level Computerized Process Control System; component concentrations values of GMA; start/stop commands of random single or daily mode of capture.

2.6.1.2. Firmware calculation module placed into a separated dynamic library “liblibloader” and under each measurement method performs calculations based on set of configurational files which describes range of calculating parameters and algorithms and theirs calculation sequence.

In such a way firmware output data depends of complex settings only. Control over reliability of output data result in following operations:

- Control over firmware calculation module inalterability;
- Check of firmware calculation module primary settings accuracy;
- Control over delivered configurational files inalterability;

2.6.1.3. Set of four double-byte digits is generated for each measurement procedure to provide safety of configurational files from alteration:

CS1 - control sum of substances physical-chemical parameters massive;

CS2 - control sum of customizable user conversations;

CS3 - control sum of calculated parameters massive;

CS4 - control sum of functions massive;

Integral control sum CS0 is formed on described above control sums basis and it is being used as specific Measurement procedure version.

Note: In certain cases, carrying of massive calculations within Measurement procedure could be carried out in separate dynamical libraries, which are also being controlled by firmware as metrologically important part.

2.6.1.4. Double-byte digit is formed and used for every library file to provide safety of controlled dynamic libraries.

2.6.1.5. Standard algorithm CRC16 based on polynomial 0xA001 with primary initialization value 0xFFFF is used to receive control sums.

2.6.1.6. Firmware identify itself at start by executable module «AnalizMAG.exe» version defining. Number of version consists of two digits divided with dots:

X.Y

Where: X - primary number which alteration means major changes in program and full incompatibility with previous versions; Y - secondary number which shows medium importance changes and do not affect on firmware metrologically important functions.

2.6.1.7. Dynamical libraries in which calculations is being performed and configurational settings files are concerned as firmware metrologically important functions. Measurement procedures in which sequence and algorithm of calculations is described.

Firmware calculation module identifies itself at start by calculation of controlled dynamic libraries CRC-codes (file “AnalizCalc.dll” etc.) and at every trigger of Measurement procedure (both mode of capture of chromatogram and archive analyses address) by calculating controlled settings files CRC-codes.

2.6.1.8. All alterations operationally carried in firmware settings and interferences of Users into its modes of operations are fixed in Interferences log. Interferences log information is stored in cypher way and therefore is protected from direct changes with text editors.

Control sums of calculation module configurational files used at the moment of calculation are stored with results of calculations during each analysis to exclude unintended and intended settings alterations. Control sums are stored in cypher way (depending of data and time of analysis performed) to prevent possibility of code overriding by hexadecimal redactors means. Control sums available both for review in methods final protocols and delivery into High-Level Computerized Process Control System.

2.6.1.9. Primary settings of firmware calculation module are braided in chromatograph integrated controller ROM on production basis of manufacturer in accordance with ordered chromatograph model.

2.6.1.10. Additional parameters that do not influence on metrologically important parts of chromatograph MAG firmware (see “Software Analyzer.Network: User manual”) setting is performed with external service software "Analyzer.Network" which is running under OS Windows series. In the meantime following actions are available:

- Chromatograph performance monitoring;

- Control over chromatograph performance (without restrictions, acc. to a right of entry);
- Firmware and its calculation module identification;
- Review of recent analyses results by flows;
- Review of archival analyses results by flows;
- Review of Interferences log events;
- Analyzed component auto search present algorithms edit;
- Time of mode of capture present events exercise edit;
- Control mixtures passports edit and creation with bounding to present modes of capture;
- Conditional-constant values of applying substances concentrations setting;
- Passport parameters for mode of capture analysis setting;

2.6.2. DESCRIPTION OF CHROMATOGRAPH “MAG” FIRMWARE.

Calculation module designed to process chromatograph data during analysis and check its reliability is included into composition of chromatograph MAG model KC 50.310-000-01 composition to process chromatograph data.

- Calibration coefficients values;
- Calibration coefficients present values range;
- Calibration coefficients present values standard of range;
- Component mole fraction values;
- Difference in received components mole fraction values;
- Standard of difference in received components mole fraction values;

2.6.3. FIRMWARE IDENTIFICATION

2.6.3.1. Firmware identification is performed by checking:

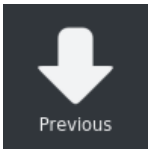
- Firmware version;
- Calculation module controlled files CRC-codes compliance to

Values specified in Type description of corresponding chromatograph model/

2.6.3.2. Firmware identification is performed with “Firmware information” conversation. (Fig. 18). Press button “Information” to open this screen form on main work window.

Firmware version and manufacturer information are displayed in upper part of “firmware information” conversation window. Upper table shows range of controlled dynamic libraries and theirs control sums.

Lower table shows range of controlled settings files CRC-codes for chosen analysis method. To navigate available list of methods you should use “up” and “down” buttons located under the table:



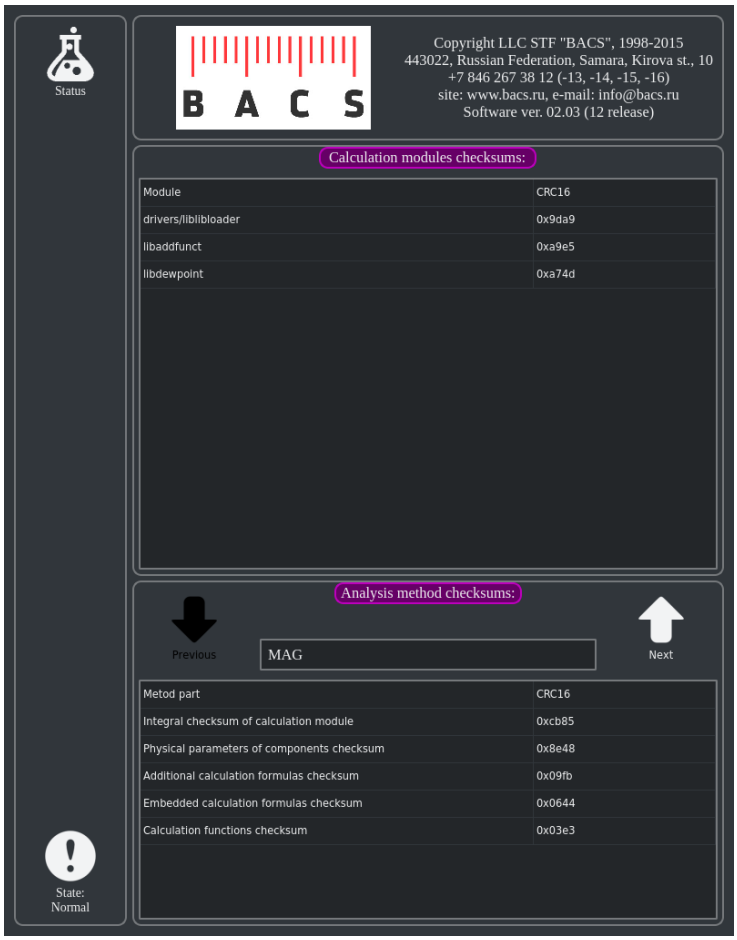


Fig. 18. “Firmware information” conversation view

To return into program main conversation press the button “Status”:

Note: In case of touchscreen absence identification of firmware is performed by software “Analyzer” or “Analyzer.Network” installed on PC (see description of corresponding software).

2.6.4. FIRMWARE CONTROL OF DEVICE

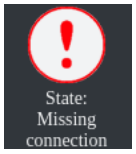
Firmware control of device is performed in device setup with display. In case of touch-screen absence control is performed by software “Analyzer” or “Analyzer.Network” Installed on PC (see description of corresponding software).

2.6.4.1. Present device status.

In bottom left corner of all windows of touchscreen graphic interface there is shown the button of present chromatograph complex status:

It shows present status of chromatograph. In chromatograph modes of capture there is settable criteria of standard and if present values do not fit set criteria of standard of loaded mode of capture this button blinks red drawing attention and looks like:

In case of absence of chromatograph microprogram connection, this button blinks red drawing attention and looks like:



By pressing this button you will get “Fault” conversation from which you can resume to previous window by pressing button “Resume”:

Appearance of “Fault” conversation is shown on Fig. 19:

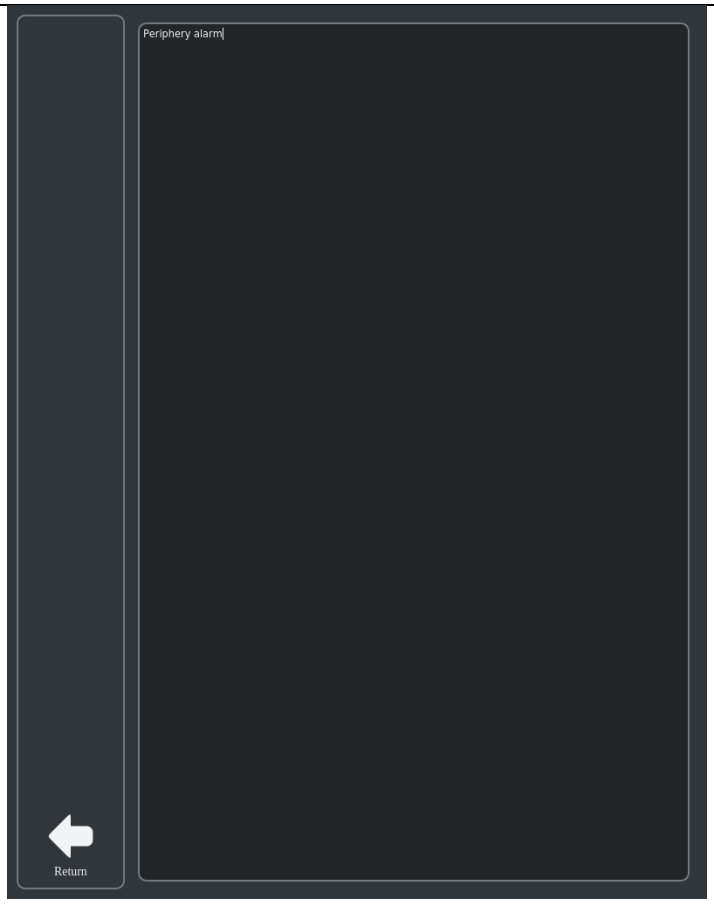


Fig. 19. Appearance of “Fault” conversation.

In case of any failures their description messages is shown in conversation.

2.6.4.2. Touchscreen conversation.

Conversation panel is shown in the left part of the screen, particularly active conversation is highlighted by color.

Inactive

Active

- Conversation “**Status**”:

Shows present state of board periphery, mode of capture and all modules in chromatograph composition (such as detector module and thermostat module);

- Conversation “**Results**”:

Shows archive results for single measurement and for particular day (considering control hour). In case of viewing work, result for single measurement there is a possibility to look directly at chromatogram.

- Conservation "**Log**" (unavailable for unauthorized user)

Shows events of "Program" log or events of "Instrumental" log for a particular period of time;

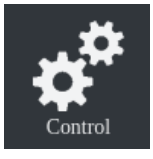
Conversation "**Information**":

Shows information about chromatograph microprogram, control sums of used methods and libraries;

Conversation "**Chromatogram**":

Shows present assembling chromatograms;

Conservation "**Control**" (unavailable for unauthorized used)



Allows to proceed control over present mode of capture: start/stop, select, manual valve control, reload of chromatograph modules, writing of settings into modules of chosen capture mode;

Conversation "**Password**":

Allows to have access to protected touchscreen conversations.

2.6.4.2.1. Conversation “**Status**” (initial conversation).

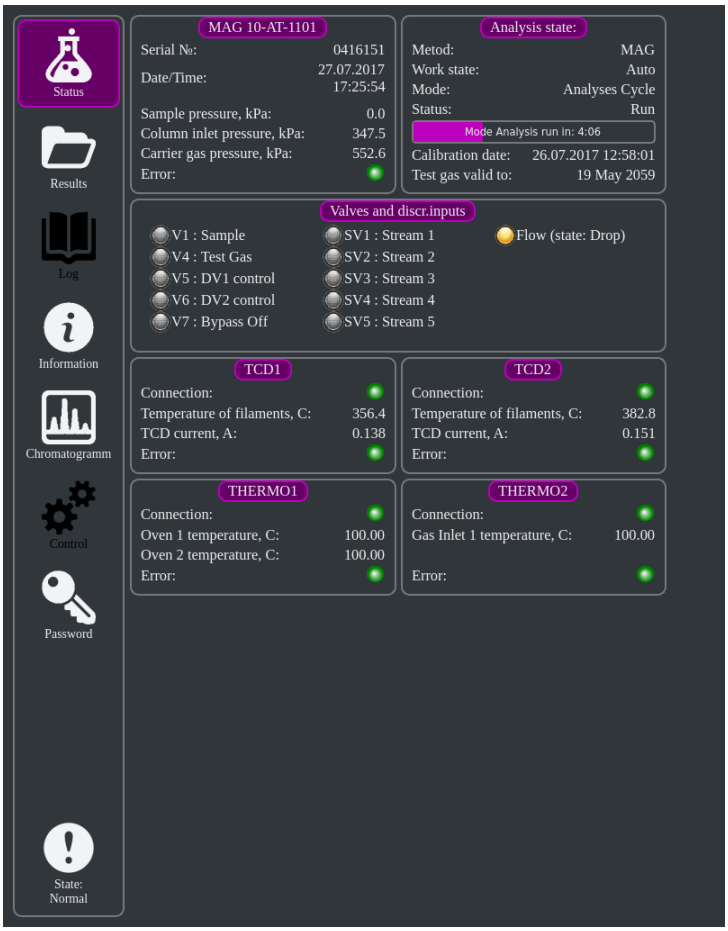


Fig. 20. Conversation “Status”:

After system loading there is conversation “Status” (Fig. 20). This conversation shows status of chromatograph complex grouped by panels.

Control panel in left part of the screen has buttons that provide switch to the corresponding conversations. Application of conversations is described in point 2.6.4.2.

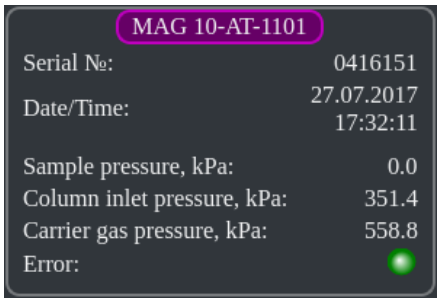
Window “**Status**” shows following panels:

Panel “MAG No.” contains aspects of motherboard such as:

- “Serial No.” — serial number of chromatograph;
- “Date/Time” — present date and time;

- Analog-to-digital converter aspects (list of shown ADC parameters and their signatures are set by service software “Analyzer”) following parameters are possible:
  - Analyzed gas pressure in kPa;
  - Input carrier gas pressure in columns in kPa
  - Input carrier gas pressure in chromatograph in kPa
  - Resistance of temperature sensor ADC BUPPKH4 in Ohm;
  - Temperature of temperature sensor ADC BUPPKH4 in Ohm;
  - relative humidity of humidity sensor BUPPKH4 in relative units;

ADC error flag BUPPKH4.

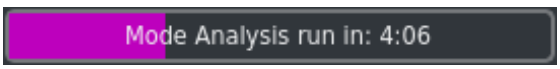


Panel “Status of analysis” contain aspects of present capture mode such as:

- “Method” - method of capture being used;
- “Capture status” — status of capture (auto, semi auto, manual);
- “Mode” — work mode (name of present capture mode);
- “Status” — status (capture in process, stand-by, stop);
- “Completion indicator” — shows present state of analysis and time before it starts or stops;

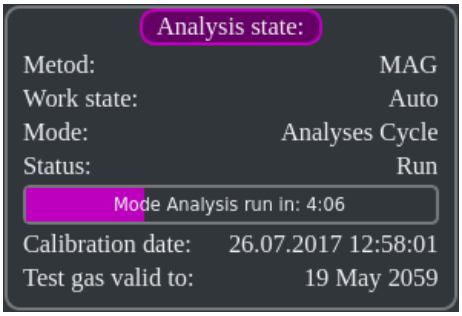
In case when analysis is in progress the indicator is moving from left to the right showing time left until analysis end.

In case when analysis is going to start the indicator is moving from right to the left showing time left until analysis start.



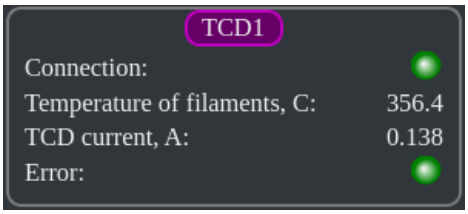
In case when chromatograph is in starting operation status and it is hard to predict time of analysis start indicator shows strip moving from left to the right

- “Date of calibration” — date of last calibration;
- “GMA valid till” — validity period of present GMA tank;

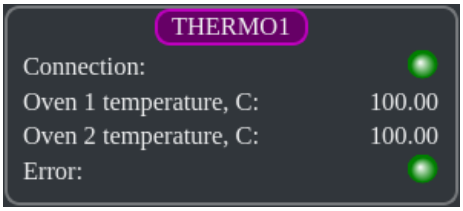


Complex modules panels such as:

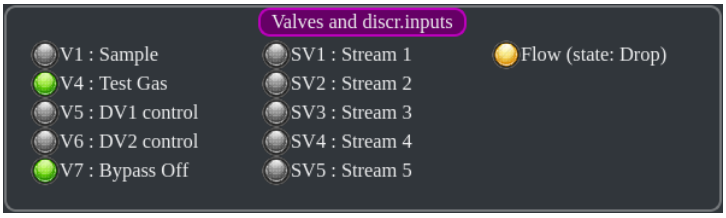
TCD module panel contains adjustable list of shown parameters and adjustable signatures for them.



Therm1 module panel (heating control boards) contains adjustable list of shown parameters and adjustable signatures for them.



Valves and digital inputs panel (of chromatograph complex) contains adjustable list of valves status and digital inputs and adjustable signatures for them:



2.6.4.2.2. Conversation “**Results**”:

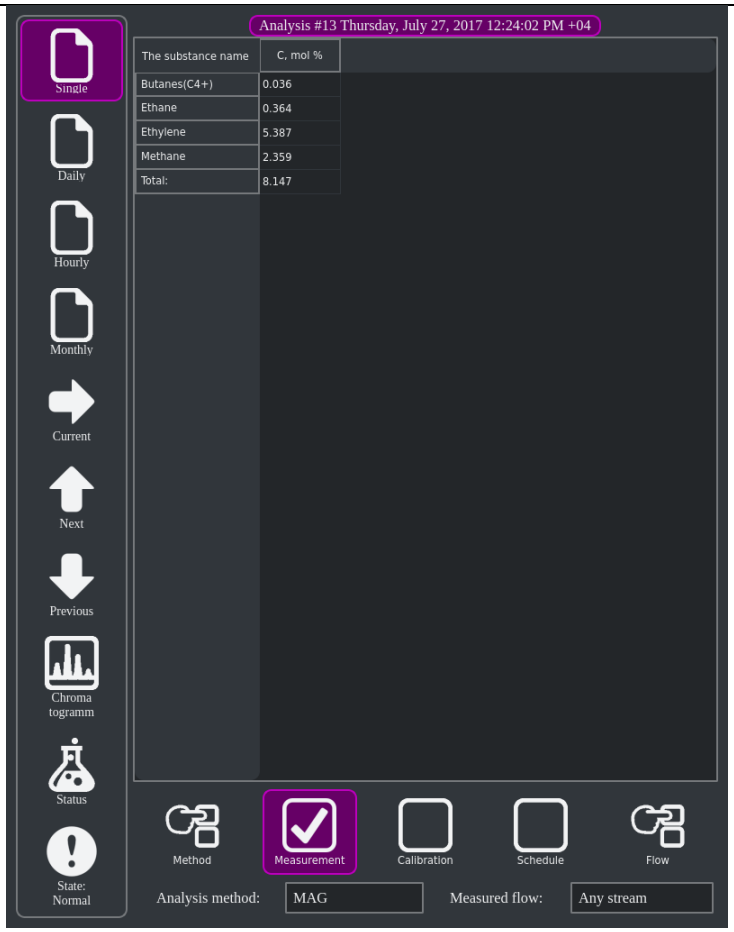


Fig. 21. Conversation “Results”:

Conversation “**Results**” (Fig. 21) allows to perform review of single analysis results and averaged analysis results confirmed valid for last day considering control hour, for hour during a day considering control hour, for a day during a month considering control hour. This conversation shows measurement results protocol you are interested in and adjustable from service software.

In case of viewing results of last single analysis, it is possible to look at the chromatogram on the basis of which results was obtained.

Control panel in left part of the screen has buttons that provide following functions:

- “Single” — makes last single analysis results protocol displayable;
- “Daily” — makes protocol of averaged analysis results that are confirmed valid for last day considering control hour displayable;
- “Hourly” — makes protocol of averaged analysis results that are confirmed valid for hour during a day considering control hour displayable ;
- “Monthly” — makes protocol of averaged analysis results that are confirmed valid for day during a month considering control hour displayable ;

- “Chromatogram” — available only during showing of last single analysis results protocol, by pressing displays chromatograph results protocol of which is being shown at the moment;
- “State” — return to “State” conversation showing present aspects of chromatograph;
- “Status” — showing chromatograph status and violation of standard criterion of capture mode in case there are any.

There are several buttons in bottom part of the screen that have following functions:

- “Method” — choosing capture method protocols of which will be shown;
- “Measurement”, “Calibration” and “Off-nominal” — choosing analysis type protocols of which will be shown correspondingly work, calibration and off-nominal;
- “Flow” — choosing flow protocols of which will be shown.

In case of activation of chromatogram, view mode conversation “Results” will have appearance as on Fig. 22.

There are several buttons in bottom part of the screen that have following functions:

- Operations with chromatogram scale is performed with lens icons — from left to right there are buttons: seizes all chromatograph area, increases scale by two times horizontally, decreases scale by two times horizontally; increases scale by two times vertically, decreases scale by two times vertically;
- There are buttons beneath for choosing detector chromatogram of which is being shown;
- Arrows allow to choose number of shown sample.

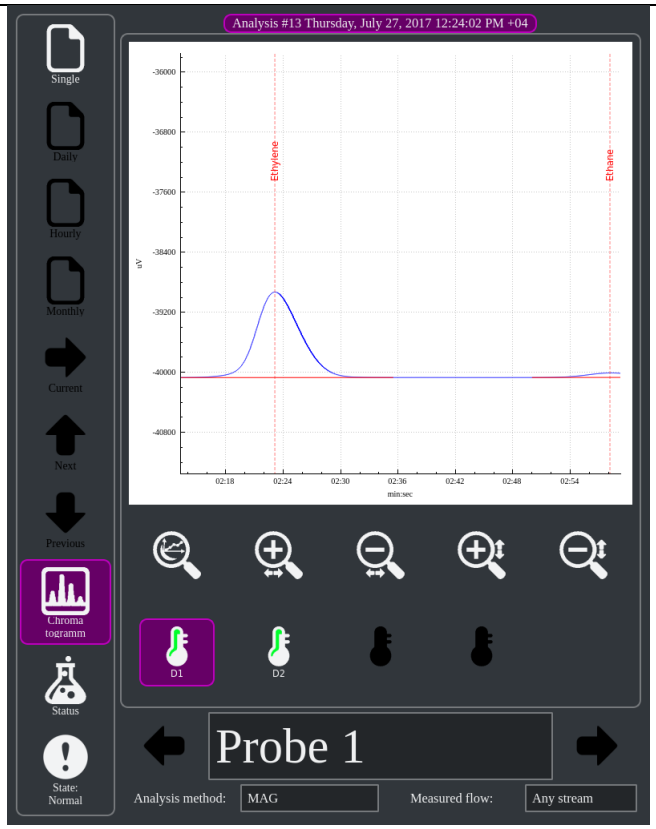


Fig. 22. Conversation “Present” — view of chromatogram.

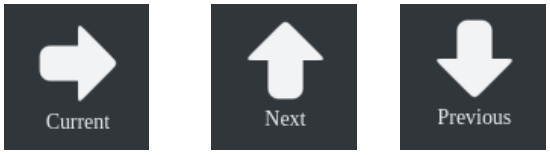


Fig. 23. Navigation buttons for results.

These buttons have following functions:

- “Present” — return to last analysis results or averaged acceptable analysis results for last day;
- “Start” — moving to the last analysis or last day;
- “End” — moving FROM the last analysis or last day;

2.6.4.2.3. Conversation “**Log**”

Conversation “**Log**” is designed to show device and program log events for chosen period of time. Conversation “**Log**” is presented on Fig. 24.

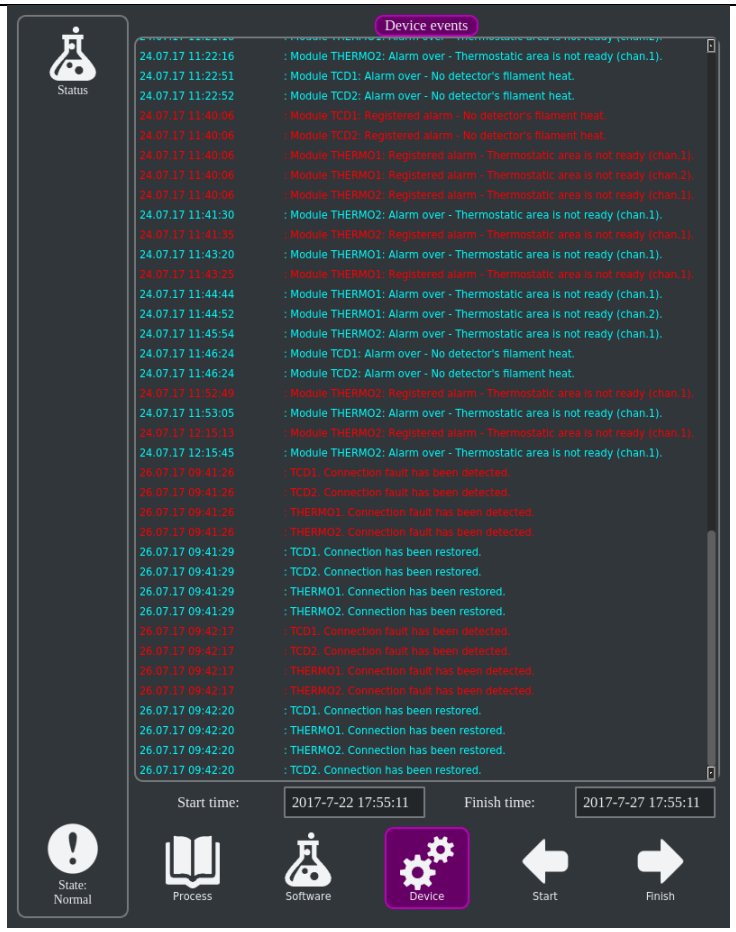


Fig. 24. Conversation “Log”

There are several buttons in bottom part of the screen that have following functions:

- “Execute” — perform receiving and display of log events in accordance with chosen settings;
- “Program” — formed selection will relate to program events log by pressing button “Execute”;
- “Device” — formed selection will relate to device events log by pressing button “Execute”;
- “Start” — define start of period according to which selection will be formed by pressing button “Execute”;
- “End” — define end of period according to which selection will be formed by pressing button “Execute”.

Form of setting date of period start and end should be:

YYYY-M-D HH:MM:SS

Where YYYY — year, M — month from 1 to 12, D — day of month from 1 to 31, HH — hour from 0 to 23, MM — minutes from 0 to 60, SS — seconds from 0 to 60.

2.6.4.2.4. Conversation “**Information**”.

Described in point 2.6.3.2

2.6.4.2.5. Conversation “**Chromatogram**”:

Shows present assembling chromatograms; Conversation “Log” is presented on Fig. 25.

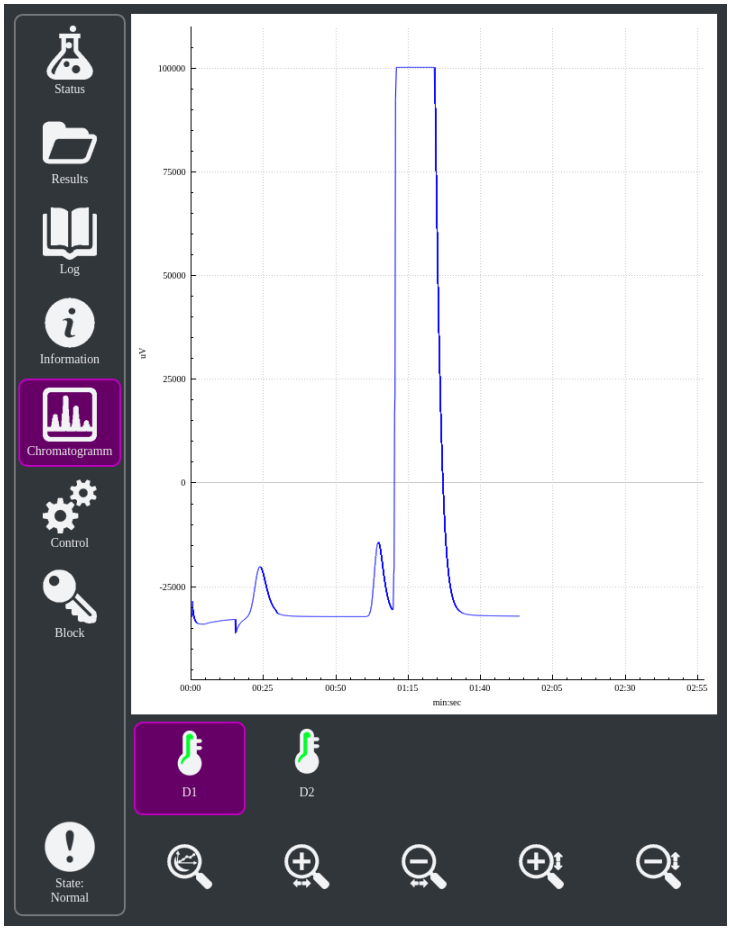


Fig. 25. Conversation “Chromatogram”:

There are several buttons in bottom part of the screen that have following functions:

- There are buttons beneath for choosing detector chromatogram of which is being shown; This buttons also displays present state of capture mod for particular detector by color: green — capture in progress, yellow — waiting for capture start according to daily capture mode, red — capture stopped;
- Operations with chromatogram scale is performed with lens icons — from left to the right there are buttons: seizes all chromatograph area, increases scale by two times horizontally, decreases scale by two times horizontally; increases scale by two times vertically, decreases scale by two times vertically;

2.6.4.2.6. Conversation “**Control**”

Allows to proceed control over present mode of capture: start/stop, select, manual valve control, reload of chromatograph modules, writing of settings into modules of chosen capture mode; Conversation “Log” is presented on Fig. 26.

Fig. 26. Conversation “Control”

Control panel in left part of the screen has buttons that provide following functions:

- “Start analysis” — start of chosen capture mode, if active than capture mode already in progress;
- “Stop analysis” — start of chosen capture mode, if active than capture mode already stopped; In case if capture is performing at the present moment according to daily capture mode and mode of soft stop mode is inactive — it activates, if soft stop mode is active, capture stops;
- “Soft stop” — start of soft stop mode, if that mode is already active then after present analysis completion daily mode of capture will be stopped;
- “State” — return to “State” conversation showing present aspects of chromatograph;
- “Status” — showing chromatograph status and violation of standard criterion of capture mode in case there are any.

“Capture mode” panel allows following parameter to set:

- “Method” — choosing capture method according to which start of capture mode will be performed;
- “Mode” — choosing capture mode from method which will start; Available only if method do not suggest using of flows;
- “Flow” — choosing flow protocols of which will be shown.
- “Auto”, “Semi auto”, “Manual” — choosing capture type: auto, semi auto and manual;
- “Meas.”, “Cal.”, “Ver.”, “Proc.”, “Off nom.” — choosing work mode type: measurement, calibration, confirmation (verification), processing and off nominal (maintenance). Available only if method suggest using of flows. Service software allows to set compliance between method capture mode (single and group) and work mode by conversation “Flow control”/

At the moment when analysis isn’t started there is flows to choose in bottom part of panel. List of available flows is set by service software. There are up to 6 flows. In case of analysis in progress or started in auto mode active flow serves as indication of on basis of which flow analysis is performed. Flow could be “Cha.” (Analyzed) and “Cal.” (Calibration) 1 calibration flow maximum;

“Manual valve control” panel allows manual valves control which are connected to main board of chromatograph.

It is possible to set parameter only if capture mode is stopped. In case of capture in progress any actions are locked and there is alarm about it

2.6.4.2.7. Conversation “**Password**”:

Allows to have access to protected touchscreen conversations. Conversation “Password” is presented on Fig. 27.

List of available users is set by service software. This is same list as for “Analyzer” software. All actions are allowed for any authorized users types, particularly for users types: “Operator”, “Chromatographer” and “Administrator”.

Fig. 27. Conversation “**Password**”:

Control panel in left part of the screen has buttons that provide following functions:

- “Symbols” — choosing of different symbols (including digits) display that available for enter;
- “Cyrillic” — choosing of Cyrillic symbols display that available for enter;
- “Latin” — choosing of Latin symbols display that available for enter;
- “Capitals” — switch between capitals and lower case symbols for enter in case of Cyrillic or Latin symbols;
- “Cancel” — cancel of password enter;
- “Apply” — apply enter of password and get access in case of its confirmation;
- “Status” — showing chromatograph status and violation of standard criterion of capture mode in case there are any.

2.7. LIST OF FAILURES

During chromatograph MAG performance analyses state of chromatograph microprogram, modules aspects by aggregating them and setting general error flag. Evens or states influencing general error flag is set in each criteria of standard.

General flag error influences on errors button state and conversation “Status”, more details in point2.6.4.1.

There are possible error messages for conversation “Status” in following table.

Table 7. List of malfunctions

Error	Actions
No connections with core module.	Reload chromatograph. Contact manufacturer.
Absence of connection with one of modules.	Reload chromatograph. Contact manufacturer.
Temperature area isn’t ready.	Reload chromatograph. Device should automatically go into mode. If repeated contact manufacturer.
Temperature sensor is damaged.	Reload chromatograph. Contact manufacturer.
PID-control error.	Reload chromatograph. Contact manufacturer.
No power on heater.	Reload chromatograph. Contact manufacturer.
Detector strings overheat.	Reload chromatograph. Contact manufacturer.
Detector strings damage.	Reload chromatograph. Contact manufacturer.
No heat of detector strings.	Check carrier gas pressure. Reload chromatograph. Device should automatically go into mode. If repeated, contact manufacturer.
Periphery error.	Reload chromatograph. Contact manufacturer.
ADC module error.	Reload chromatograph. Contact manufacturer.
Overshoot of technological limit.	Some monitored value in technical limit of standard criteria of active capture mode is out of set range. Use service software to detect which exactly and undertake corresponding actions.
Overshoot of technological limit.	Some monitored value in technical limit of standard criteria of active capture mode is out of set range. Use service software to detect which exactly and undertake corresponding actions.

3. MAINTENANCE

3.1. PREPARATION FOR MAINTENANCE

CAUTION!

- Ensure power supply is disconnected before chromatograph maintenance. Wait 30 minutes after power supply disconnection;
- Prevent gas supply before maintenance;
- Calibrate after chromatograph maintenance before start in operational mode;
- Check connections on sealing if maintenance involved dismantling of pipes or fittings weakening.

3.2. PROCEDURE OF MAINTENANCE

Chromatograph maintenance includes periodical checking of technical state and metrological check. Chromatograph maintenance should be performed by manufacturer or authorized service center specialists or by engineering and technical personnel of customer who received special training according to present “Rules for Operation of Consumer Electrical Installations” (RTI), Safety Rules for Operation of Customers' Electrical Installations (RS), Electrical Installation Regulations (EIR ch. 7.3 and other), this manual for chromatograph and its related software operation. Maintenance related to seals removing is performed only by manufacturer or authorized service center specialists.

3.3. CONTENT OF MAINTENANCE

Metrological characteristics of chromatographs during verification interval meet set standards upon condition of consumer observing rules of storage, transportation and operation according to this manual. Forms and cycles of maintenance adjusted in table blow.

Table 8. Forms and cycles of maintenance

No.	Forms of maintenance	Cycles
1	Routine maintenance	Every day
2	Periodical inspection of technical state	Not less than once a quarter
3	Preparation for maintenance	Not less than once a year

3.3.1. CHROMATOGRAPH ROUTINE MAINTENANCE

Routine maintenance is periodical (one time a day) control over chromatograph performance.

It is necessary to control:

- Temperature and pressure of environment in chromatograph location;
- Alteration of carrier gas tank pressure (if tank pressure reaches 2 MPa, it is necessary to make corresponding event in operational log and report tank replacement as necessary);
- Alteration of calibration mixture tank pressure (if tank pressure reaches 0.5 MPa, it is necessary to make corresponding event in operational log and report tank replacement as necessary);
- Analyzed gas flow (by rotormeters of samples preparation unit);
- Chromatograph breakdown absence (if there's an alarm indicator in software “Analyzer.Network” or on LED panel with red color, it is necessary to make corresponding event in operational log and report a breakdown).

3.3.2. PERIODICAL INSPECTION OF TECHNICAL STATE

Operated chromatograph is needed in periodical control of technical state, which consists of following events:

- Operation conditions compliance verification;
- Stickers, seals, warnings and ex-proof mark security verification;
- Device external surfaces cleanness verification;
- Chromatograph pipe connections sealing verification:
- External damage absence verification;
- Electrical connections verification;
- Carrier gas flow verification;
- Carrier gas tank pressure and GMA presence verification and replacement if needed;
- Control measurement performance for calibration verification.

Inspection is performed in periods defined by operational organization joint with service organization which performs maintenance of object where chromatograph is set but not less than once a quarter

3.3.3. PREPARATION FOR MAINTENANCE

It is necessary to perform inspection of chromatograph once a year according to the document “Process gas chromatograph MAG”. Model KC 50.310-000-01. Method of verification MP 242-1616-2013".

3.3.3.1. Chromatograph preparation for annual metrological verification consists of following events:

- Input devices, sealing, grounding quality verification;
- Warnings, ex-proof marking and its accordance to placement class and explosion environment verification;
- Threaded connections integrity and ex-proof covers fasteners presence verification;
- Ex-proof surfaces damage absence verification (it is forbidden to operate a chromatograph if sinks, match marks defects are detected or splits enlargement over limits set by GOST 22782.60;
- Carrier gas, analyzed gas and calibration gas pipeline sealing verification;
- Required carrier gas, analyzed gas and calibration gas consumptions and pressures settings verification;
- Capture mode settings verification;
- Chromatograph peaks automatic calculation settings verification;
- Switch valves and valves work capacity verification;
- Metrological characteristics calculation accuracy verification;
- Device software hash codes accuracy verification;
- Filter cleanness verification (replace internal filters if necessary);
- For chromatograph models with TCD or CCD: in case of appearance on chromatogram parasite peaks of calibration or control gas mixture, deformation and null line drift increase it is necessary to performs replacement of carrier gas filter drier (**F1,** see chromatograph pneumatic diagram in Appendix A).

3.3.3.2. ECD sensor replacement;

During performance of operations for preparation to chromatograph MAG with ECD detector verification, it is recommended to replace the ECD.

To replace the ECD sensor it is necessary to:

A) screw off chromatograph ex-proof box cover takedown screws;

B) screw off ECD thermostat cover 2 screws (A1.2., Fig. 5), remove cover;

C) unplug ECD preapplication board cable (Pos. 2, Fig. 9);

D) screw off by hand and extract ECD cover (Pos. 1, Fig. 9), together with board and sensor;

E) replace ECD (Pos. 3, Fig. 9);

F) perform installation in reverse way

It may need 24 hours of non-stop chromatograph performance to stabilize sensor performance. So it is recommended to perform chromatograph verification not earlier that after 24 hours of non-stop performance after ECD sensor replacement.

3.3.3.3. Filling ECD dumper container with water.

Amount of water in ECD dumper container selected in a way that there will be enough for one year of non-stop device performance (during calibration interval) in a purpose to match together chromatograph preparation for verification and dumper container filling by water procedure. Although actual water consumption depends on chromatograph operational conditions so that dumper container filling could be required earlier. The signal of dumper container filling required is drastic reduction of carrier gas humidity level, which is being registered by humidity sensor and shown on chromatograph display and in "Analyzer" software on remote PC. Normal value of humidity is not less than 10%. To fill ECD dumper container it is required to:

A) screw off chromatograph ex-proof box cover takedown screws;

B) unclasp stickup which is locking dumper container;

C) screw off dumper container cover;

D) fill it with water while it is turned;

E) perform installation in reverse way

Note: *Use only distilled water for dumper container filling.*

4. TRANSPORTATION, STORAGE AND DISPOSAL

4.1. TRANSPORTATION

It is allowed to transport packed chromatograph on any distance and by type of vehicle, besides unpressurised plane bays and open decks while following storage conditions acc. to GOST 15150-69. While transporting, protection of transportation packaging from atmospheric precipitation should be provided. Transportation conditions:

- Environment temperature from -40 to +50°C;
- Relative air humidity under 100% at 25°C;
- Consistence of dust and contaminations in the air is unacceptable.

Way of stowing boxes in transportation vehicle should exclude their movements. Transportation of boxes shouldn’t be affected by drastic shocks and atmospheric precipitation intervention during handling.

For chromatograph model with ECD sensor. At temperature lower than -20°C transportation of ECD that are part of chromatographs should be carried out separately at temperature from -20 to +50 °C. It is allowed to transport sensor as a part of analyzer upon observing temperature range described above. It is necessary to remove dumper container from chromatograph and dry it during transportation.

Unpacking of chromatograph should be performed in dry heated places after daily storing in them in case if environment temperature during transportation was lower than 5°C.

4.2. STORAGE

Chromatograph in a packed state should be stored in closed place in accordance with conditions 2 of GOST 15150:

- Air temperature from -40 to +50 °C;
- Relative air humidity under 98% at 25 °C;
- Consistence of acid fumes, alkali fumes and other contaminants is unacceptable.

Keeping close to heating devices is unacceptable.

For chromatograph model with ECD sensor. Storing of ECD which are part of chromatographs should be carried out separately at temperature from 0 to +40 °C. It is acceptable to leave sensor in chromatograph while long-time storing upon observing temperature range of sensor storage. It is necessary to remove dumper container from analyzing unit and dry it during storage.

4.3. UTILIZATION

Chromatographs do not content hazardous substance components that are dangerous for health and environment during and after service life and dismantling. Chromatograph dismantling is performed separately by groups of materials: plastic elements, metal elements of body and fasteners.

4.4. WARRANTY SERVICE

Manufacturer guarantees accordance of chromatograph MAG to requirements TU 4215-015-21189467-2011 IF CONSUMER IS OBSERVING CONDITIONS OF INSTALLATION, OPERATION, TRANSPORTATION AND STORAGE.

Warranty period of chromatograph MAG operations is 12 month since implementation but no longer than 18 month since moment of shipping to consumer.

Consumer loses warranty service in following cases:

- commissioning operations during implementation was carried out not by manufacturer of authorized service center specialists.
- operation and service of chromatograph was carried out by unprepared personnel not acquainted with user manual of device;
- malfunction of chromatograph happened due to violation of user manual requirements by consumer;
- chromatograph has mechanical damage.
- chromatograph underwent dismantling or any other interferences into device construction without coordination with manufacturer.

Breakdown of filters F1, F2, F3 of chromatograph MAG in consequence of carrier gas unacceptable quality (requirements are set in p. 1.2.1 of Maintenance guide KC 50.310-000-01) isn’t a warranty event.

Warranty repairs is performed at manufacturer unless otherwise is foreseen by additional agreement between consumer and manufacturer.

After the warranty period, manufacturer performs post-warranty service of chromatograph by means of standalone agreement with consumer.

Manufacturer
STF "BACS" LLC, Samara
Address: 443022, Samara, Kirova ave., 10

APPENDIX A

Specifics of design and operation of process gas chromatograph MAG model KC 50.310-000-01.XXX

Application Data Sheet

This appendix is mandatory and contents information about specifics of design, connection, gas diagram, list of analyzed components, analytic channels parameters and connection interfaces for particular chromatograph model provided to consumer as solution for particular analytic problem.

Revision record sheet

KC 50.310-000-01 RE

	Numbers of sheets			Total sheets in document	Reason of changes	Responsible for changes	Sign.	Date
Rev.	Changed	Replaced	New					