APPROVED BY

General Director of

STF “BACS” Ltd.

_____ Ildar Bibaev

«___» _____ 2013

# Process Gas Analyzer model «AnOd» КС 50.250-000

OPERATING MANUAL

КС 50.250-000 РЭ

Samara

2013

## Content

The present Operating Manual is applied to the process gas analyzer “AnOd” (hereafter - “analyzer”) КС 50.250-000 which is intended for measurement of mass concentration of mercaptans in gas phases, including in natural gas.

# 1 Description and work

## 1.1 Application

1.1.1 Analyzer is intended for measurement of mass concentration of mercaptans (in equivalent to ethylmercaptan) in gas phases, including in natural gas and transmission data to external devices.

1.1.2 Analyzer may be used within fiscal metering and quality control systems in accordance with GOST 5542-87 and STO Gazprom 089 requirements at gas-distributing stations or gas-distributing points.

1.1.3 Analyzer is intended for continuous work in automated mode for a long time.

1.1.4 Analyzer has explosion proof design with marking 1ExdIICT4 Gb, complies with the requirements of GOST R 52350.0, GOST R 52350.1, GOST R 52350.11 and may be installed in explosion-proof areas (Electrical installation code, rev.6 ch.7.3 2001, GOST R 52350.10) according to explosion protection marking.

Protection level from environmental influence – IP66 according to GOST 14254.

Climatic modification – UHL 3.1 according to GOOST 15150.

## 1.2 Specifications

1.2.1 Energy consumption during operation:

– analyzer is supplied with alternating current with voltage $220^{+22}_{-33}$ V and frequency (50±1) Hz;;

– maximum power consumption: up to 90 W while hating up;

up to 30 W in operating mode;

1.2.2 Parameters of analyzed gas mixture:

– analyzed mixture – natural gas according to GOST 5542-87;

– temperature of analyzed mixture 0-50 °C;

– pressure of analyzed mixture 0,2-1,2 MPa;

– mechanical impurities concentration in analyzed mixture shall not exceed 10 mg/m$^3$ with particle size not more than 5 μm.

Analyzer gas lines are sealed under pressure equal to 1.2 of maximum working pressure. Drop in pressure for 30 min – not more than 10% of supplied pressure.

1.2.3 Reliability characteristics:

– Mean time before failure – 20000 h;

– Average expected lifetime – 10 years.

1.2.4 The main technical characteristics are shown in table 1.

Table 1. The main technical characteristics

| **Parameter name** | **Value** |
|---|---|
| Ambient temperature at the place of installation | from +5 to +50 °C<br>from -40 to +50 °C (option)* |
| Ambient pressure at the place of installation | 84,0-106,7 kPa, at relative humidity up to 98% without moisture condensation |
| Size: length×width×height, mm×mm×mm | 435×275×425 |
| Weight not more than, kg | 39 |
| Cable inlets | Type FAL (FAL S1) or PAP |
| Ventilation device | ECDS110 или ECD |
| Fitting on the input | 1/16" or 1/8” tube |
| Temperature mode of the analyzer | Isothermal from +40 to +50℃ |
| Sample pressure regulator | Mechanical |
| Detector type | Electrochemical |
| Phase of analyzed mixture | Gaseous |
| Consumption of analyzed gas | 20 – 60 ml/min |
| Analysis cycle time, min | from 5 |

* with heated sample inlet КС 50.912-300.

1.2.5 Metrological characteristics of analyzer are listed below.

Table 2. Metrological characteristics

| Indication range of mass concentration of mercaptans (R-SH) in equivalent to ethylmercaptan ($C_2H_5SH$), mg/m$^3$ | Measurement range of mass concentration of mercaptans (R-SH) in equivalent to ethylmercaptan ($C_2H_5SH$), mg/m$^3$ | Maximum allowed uncertainty**, % | |
|---|---|---|---|
| | | reduced | relative |
| from 0 to 100 | from 0,0 to 10 | ± 25 (± 20) | |
| | from 10 to 100 | | ± 25 (± 20) |
| Notes:<br>1) * - indication range of mass concentration of mercaptan sulfur - from 0 to 50 mg/m$^3$;<br>2) ** - is determined during the analyzer ordering and depends on the verification method. | | | |

1.2.6 Heat up time of analyzer – less than 1 hour.

*Note: there may be up to 12 hours of continuous operation required after a long storage or replacement of the permeation tube to achieve an equilibrium in it and therefore to provide reliable calibration.*

## 1.3 Supplied configuration

Table 3. Supplied configuration of the “AnOd” gas analyzer.

| Denotation | Name | Q-ty |
|---|---|---|
| КС 50.250-000 | “AnOd” gas analyzer | 1 |
| | Package | 1 |
| | Spare parts, tools and equipment set | 1 |
| КС 50.250-000 РЭ | Operating manual | 1 |
| КС 50.250-000 ПС | Passport of analyzer | 1 |
| КС 50.250-000 34 01-1 | “X-meter” software manual | 1 |
| | Installation “X-meter” software CD | 1 |
| МП-242-1659-2013 | Verification methodology | 1 |
| | Copy of Type approval certificate | 1 |
| | Copy of Certificate of conformity of the Customs Union | 1 |

## 1.4 Design of analyzer

1.4.1 Exterior view of analyzer.

Exterior view of analyzer is shown on figure 1 below.

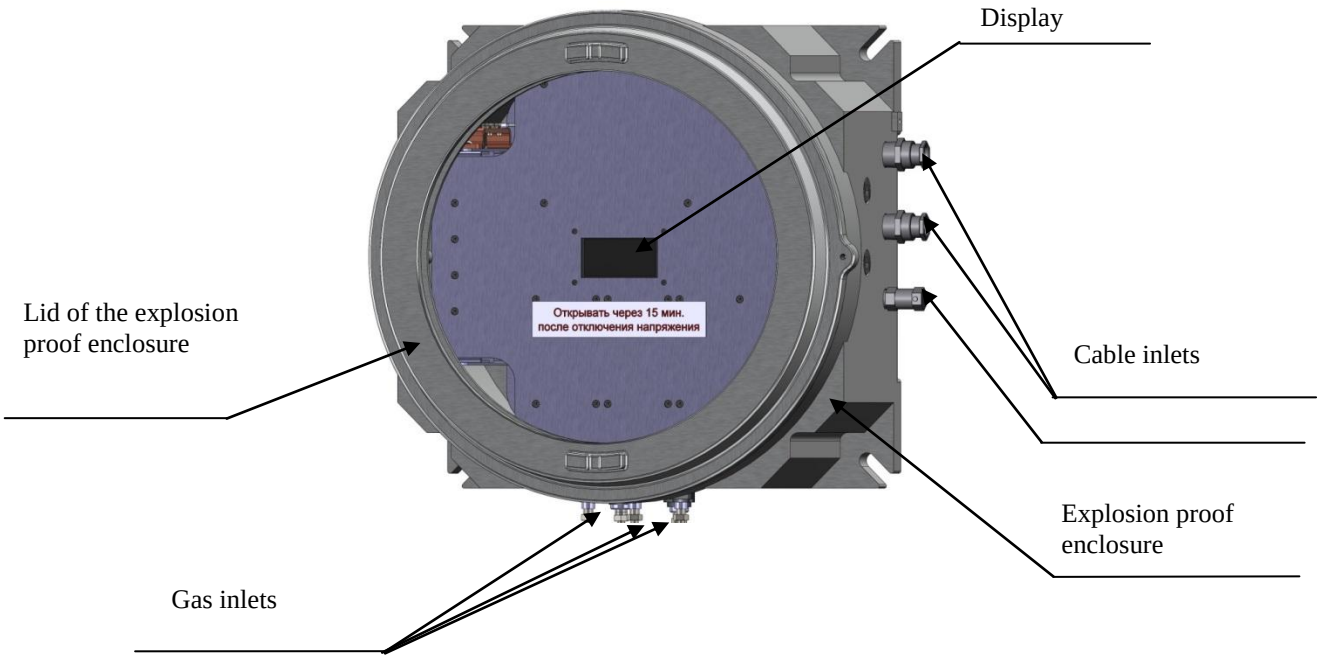



Fig 1. Exterior view of “AnOd” analyzer

1.4.2 Internal design of analyzer.

There are analytical and electronic units located inside of the explosion proof enclosure (Fig. 2)

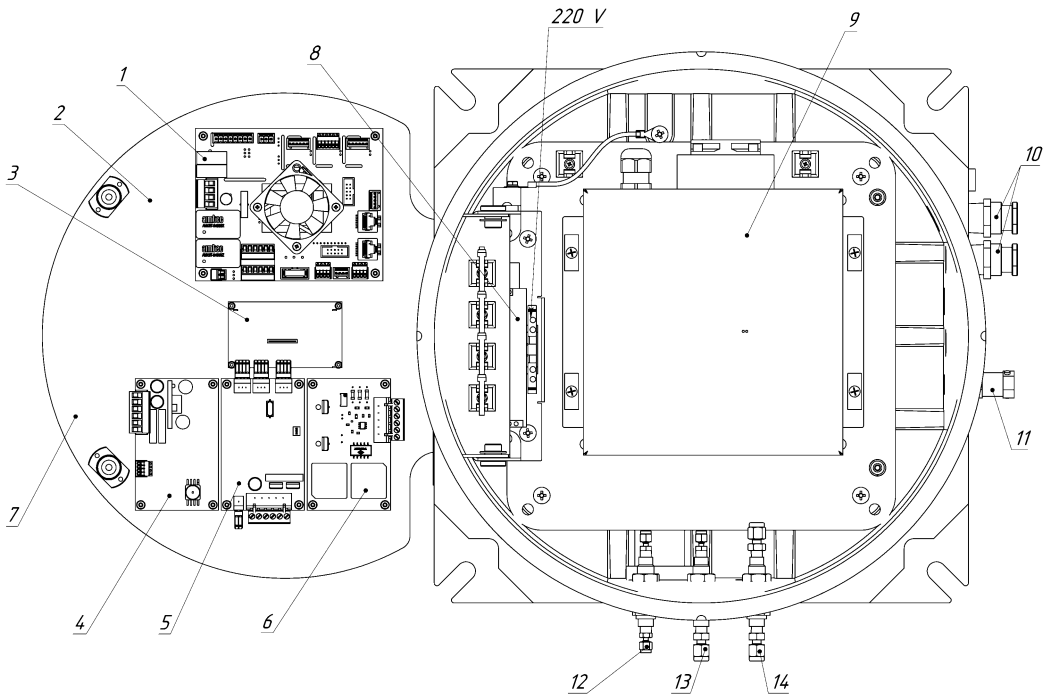



Fig. 1. Internal design of analyzer. Overall layout.

The following elements are specified on the figure above:

1 – control board;

2 – lid;

3 – display;

4 – defense board;

5 – heating board;

6 – the board for control of Peltier element;

7 – power supply unit;

8 – thermostat;

9 – cable inlets;

10 – ventilation device;

11 – sample inlet;

12 – waste;

13 – detector’s waste.

### 1.4.3 Description of the analytical unit

The analytical unit is shown on fig. 3.

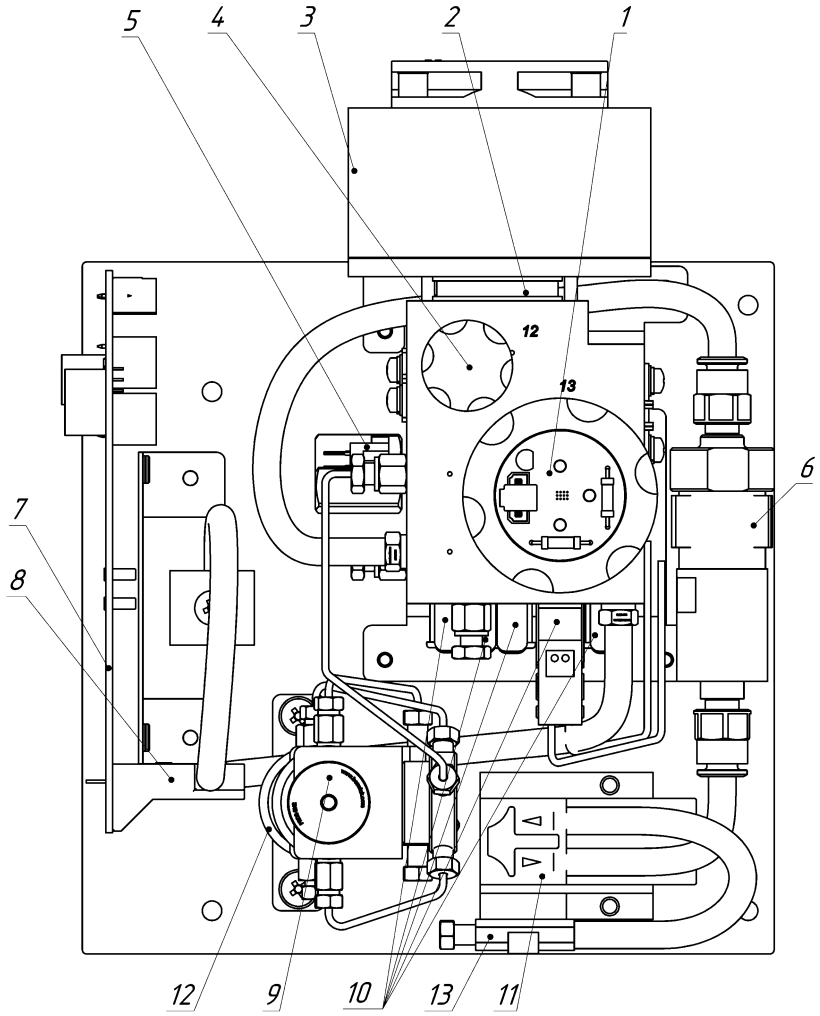



Fig. 3. Internal design of the analytical unit.

The analytical unit consists of the following elements:

1 – electrochemical detector (ECD);

2 – Peltier element;

3 – radiator;

4 – permeation tube with ethylmercaptan for periodic calibration of analyzer;

5 – pressure sensor;

6 – absorber for sulfur-containing compounds;

7 – ECD board;

8 – flow sensor;

9 – sample pressure regulator (mechanical);

10 – solenoid valves;

11 – electrical pump for air supply;

12 – relief valve;

13 – frit filter (2 μm).

## 1.5 Operating principle of analyzer

### 1.5.1 General information

Analyzer uses an electrochemical detection principle based on oxidation of sulfur-containing compounds (mercaptans) which are used as components of odorant of the natural gas.

Analyzed gas is continuously flushing through the sampling loop and it is being periodically injected into the separation column by the electrical pump. The separation column is used for dividing the hydrogen sulfide, which is an interfering component, from mercaptans which are detected further by the electrochemical detector without separation onto individual components. An obtained signal corresponds to total concentration of mercaptans in analyzed gas.

The calibration of analyzer is performed periodically in order to provide accurate and stable results of measurement. This procedure is performed automatically by using an internal permeation tube with ethylmercaptan and doesn't require to be controlled by operator.

*Analyzer do not require any additional gases such as carrier gas or calibration mixture.*

### 1.5.2 Principle of operation of the ECD

Electrochemical detector is based on the appearance of electric current when substances capable of oxidation - in this case, hydrogen sulfide, mercaptans and sulfides – pass through detector. The instrument uses diffusion type, in which the gas is separated from electrolyte and electrodes by a thin membrane. Detector design is shown in Fig. 4.

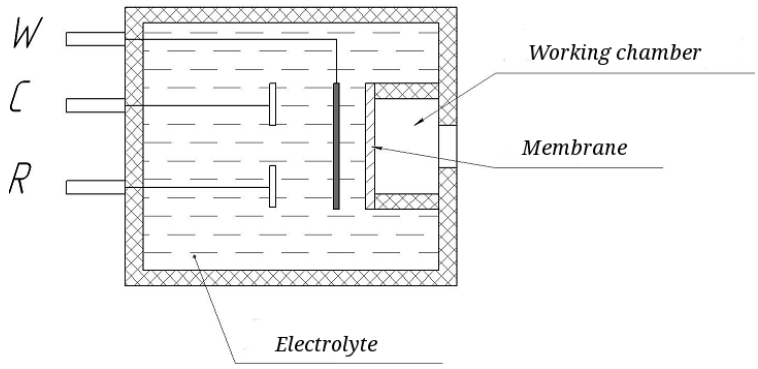



Fig. 4. Electrochemical detector design

Working electrode (marked with letter W) may provide the following oxidizing reactions of sulfur compounds:

hydrogen sulfide $H_2S + 4H_2O = SO_4^{2-} + 10H^+ + 8e$

mercaptans $RSH + 3H_2O = RSO_3H + 6H^+ + 6e$

$RSH + H_2O = RSO + 3H^+ + 3e$

$2RSH = RSSR + 2H^+ + 2e$

The working electrode is coated with catalyst layer, so that oxidation occurs under mild conditions. The catalyst is selected in such way that it allows oxidizing of only sulfur-containing components. ECD does not provide a response to hydrocarbons, nitrogen, carbon dioxide, which makes it easy to determine the sulfur compounds in natural gas

Calculational electrode (marked by letter C) allows oxidant reducing reactions. As an oxidizer ECD uses aerial oxygen. In this case the electrode allows the following reaction:

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

For normal operation of ECD oxygen concentration in detector chamber shall be at least 0.1% by volume.

The third electrode is a comparative one (marked by letter R) and serves to maintain constant potential of working electrode. In diffusion type ECD limiting stage is the diffusion of test components to the working electrode. In this case, detector current is proportional to the concentration of measured component in gas *Ci*, the diffusion coefficient *D* and the number of electrons *n* according to reaction equation:

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

The advantage of ECD membrane is that it does not require servicing during calibration interval (the membrane minimizes entrainment of electrolyte). The response time of ECD depends on the thickness of the membrane. The maximum operating temperature of ECD is usually not more than 50 ° C.

# 2 Intended usage

## 2.1 General Instructions for Operations

2.1.1 Analyzer is a complex device connecting elements of electrical and instrumentation equipment, gas flow control, pneumatic automation. Before analyzer mounting in the field it is necessary to check it in the laboratory in automatic mode.

2.1.2 During operation it is necessary to watch over chromatograph operation. If any changes during the process appear, it is necessary to check analyzed gas pressure and flow, gas lines sealing and look through analyzer event log.

## 2.2 Allocation and Mounting

2.2.1 Analyzer is placed on production facility in accordance with the requirements of the present OM.

2.2.2 Instrument mounting includes connection of:

- analyzed gas line;
- waste lines for products of analysis;
- electrical communications binding instrument with external devices;
- power supply 220 V.

2.2.3 Gas line connection is accomplished by pipe 1/8” with internal diameter 2 mm or pipe 1/16' '.with internal diameter 1 mm.

2.2.4 To fix analyzer to the wall or the frame on production facility, one shall follow outline drawing (appendix A).

2.2.5 Analyzer is mounted stationary outdoor under a visor protecting against direct sunlight or on a heated shelter.

2.2.6 Analyzer shall have free access from three sides.

2.2.7 Allowed temperature in the place of installation is from -40 to 50 °C with heated sample inlet КС 50.912-300 or from +5 to 50 °C without one at relative humidity of not more than 98 %.

2.2.8 The instrument shall be placed over a distance from powerful heat sources. Minimum distance between the instrument and heat source shall be 0.5m.

## 2.3 Installation, Setting-Up, Start-Up Procedures

2.3.1 Analyzer installation on the process facility. To operate on the process facility the installation shall be made taking into account instructions, stated in section 1 of the present OM.

2.3.2 Analyzer shell be placed as close as possible to a point of sampling.

2.3.3 Explosion protection means checking. Checking is accomplished by means of visual inspection. Surfaces of the parts, providing explosion protection, shall not have cuts, scratches, dents, perishing, damages of threads of screws. Defect parts shall be rejected and replaced by new ones, supplied by manufacturer. Plates presence and inscriptions accuracy, content and quality of explosion protection marking and its correspondence with active certificate are to be checked.

2.3.4 Preparation to operation and turning on of the analyzer include the following:

2.3.4.1 Gas lines connection for analyzed gas and wastes is accomplished according to fig. 5. Unmarked gas inlets are closed with plugs.

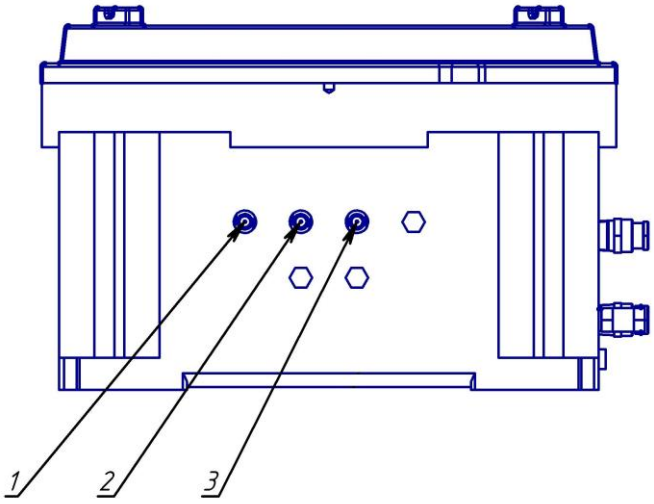



Fig. 5. Gas inlet assignment

1 – sample inlet;

2 – sample waste;

3 – detector waste.

Gas lines connection to the corresponding analyzer outputs is accomplished with pipes 1/8” with internal diameter 2mm or 1/16" with internal diameter 1mm (AISI 316) using the adapters with compression fitting supplied.

Analyzer vent lines shall be connected to enterprise discharge lines without jump-in pressure.

2.3.4.2 Connection of electric circuits to analyzer.

Diagrams of connections and designations of connectors and electronic units of the instrument are supplied (see appendix B).

Analyzer gets electric power through shielded copper-conductor cable with size not less than 1.5mm$^2$. There are three conductors in the cable. Cable for data transfer is led by armoured twisted pair cable shielding of every pair and cross-section of conductor not less than 0.5mm$^2$. There are three twisted pairs in the cable. Cable types and requirements to wring and mounting correspond to Electrical installation code (rev. 6).

Analyzer shall be grounded with earthing clamps to special external grounded bar.

Connection shall be accomplished in accordance with electrical interconnect diagram presented in appendix B. Cable input is accomplished in accordance with box main view (fig. 1). All cables are connected to analyzer control board.

To connect cables do the following:

- open the lid of the explosion proof enclosure;
- connect power supply cable to socket XS3 (appendix B);
- connect analyzer to the remote workstation by means of standard 4-20 mA interface, and/or Ethernet and/or RS 232/485 (sockets X12, X14, X1 on the board correspondingly, appendix B).

2.3.4.3 After connecting of gas and power supply to analyzer the current concentration of odorant, mercaptan sulfur and current status information must be shown on the display located under the glass on the lid of explosion proof enclosure.

## 2.4 Operating procedure

2.4.1 Connection.

The “X-meter” software is used for setting and control of analyzer operations. Setting up of connection between analyzer and external PC is performed according to Software Manual using the “X-meter” software supplied with analyzer.

2.4.2 Setting up the instrument.

The following parameters are to be configured:

- frequency of analyses (period of time between analyses);
- frequency of calibrations (number of analyses between calibrations);
- values of upper and lower thresholds of odorant concentration;
- mass fraction of mercaptan sulfur in used odorant;
- flow of analyzed gas through the analyzer (is to be tuned manually by pressure regulator).

These settings are performed by the “X-meter” software. After that instrument can be switched into automatic operation mode.

2.4.3 Measurements.

2.4.4 Analyzer “AnOd” is intended for measuring of odorant amount in natural gas in automatic mode. After starting up analyzer goes to the automatic mode and operates according to its settings. Analyzer can be switched into the manual mode by “X-meter” software (see the Software Manual).

It is required for all gas lines of analyzer to be purged well with analyzed gas before use. For this purpose 10-20 preliminary analyses should be performed.

2.4.5 Calibration.

Calibration is performed automatically using internal permeation tube with ethylmercaptan. An atmospheric air supplied by electric pump and passed through absorber for removing traces of sulfur-containing compounds is used as carrier gas for permeation tube.

## 2.5 Software

2.5.1 There are two kinds of software used with analyzer “AnOd”:

- internal;
- stand-alone.

The internal software designed for collection, processing, storage, presentation and transmission of data during analyzer operation.

2.5.2 The internal software realizes the following algorithms:

1) Manual operation — performing of operator's commands;

2) Automatic operation — performing analyses according to preset algorithm.

During its operation the internal software do the following:

- ensures protection and control of metrologically significant parts of program and saved data;
- fixes changes in settings and user's interruptions in the Intervention log;
- performs identification of software and its calculation module;
- provides transmission of data into high-level control system via Modbus RTU protocol.

2.5.2.1 Identification of the internal software is performed by means of checking:

1 - version of internal software;

2 - correspondence of CRC-codes of controlled programs to its passport values.

2.5.3 Stand-alone software «X-meter» for Microsoft Windows XP/Vista/7/8 is intended for setting and control of analyzer operations.

2.5.3.1 Stand-alone software fulfills the following functions:

1) At the user level:

- output the measurement results on the display of PC;
- identification of the internal software and its calculation module;
- reviewing results of analyses;
- reviewing the Intervention log;
- reviewing the Errors log.

2) At the administrator level:

- setting of the operation modes of analyzer;
- setting of the allowed values of controlled parameters;

- settings of the communication ports;
- user's access rights management;
- time synchronization;
- internal software update;
- setting the parameters of internal permeation tube;
- setting of the 4-20 mA output.

2.5.3.2 Stand-alone software identification is performed using “About...” window. (Help\About...), see fig. 6. Version of used software is shown in the top part of the window. Version of internal software and it's CRC-codes are located in the bottom part of this window.

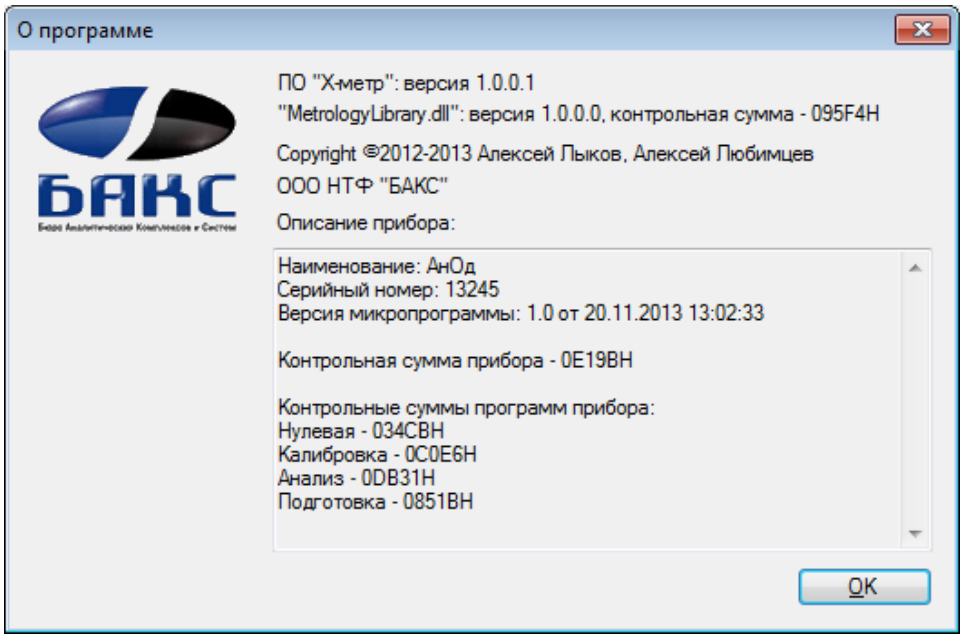



Fig. 6. About «X-meter» software

More detailed information about using the “X-meter” software can be found in the Software Manual supplied with analyzer.

## 2.6 Fault list

During operation analyzer “AnOd” software generates messages, specifying the start or the end of any operation, as well as errors and faulty operations. All messages are automatically entered into electronic analysis protocol by software. Table 4 presents the list of error messages and operator actions in case of their receiving.

Table 4. Fault list.

| Error | Actions |
|---|---|
| Error of channel setting | Loss of connection with channel control circuit. Switch off the instrument. Contact manufacturer. |
| No connection with ADC module | Loss of connection with KC50.251-200 board. Switch off the instrument. Contact manufacturer. |
| No connection with thermostat | Loss of connection with KC50.252-100 board. Switch off the instrument. Contact manufacturer. |
| Parameter value is lower than a defined minimum. | Check current values of instrument parameters. If parameters which are out of defined range are related with hardware working (pressure, flow, temperature, etc.) then try to provide the required conditions or wait until instrument achieve these conditions or switch off the instrument and contact manufacturer. If these parameters are related with calculated values then make sure that these parameters (such as odorant concentration) are normal indeed before considering it as an error. |
| Parameter value is higher than a defined maximum. | Check current values of instrument parameters. If parameters which are out of defined range are related with hardware working (pressure, flow, temperature, etc.) then try to provide the required conditions or wait until instrument achieve these conditions or switch off the instrument and contact manufacturer. If these parameters are related with calculated values then make sure that these parameters (such as odorant concentration) are normal indeed before considering it as an error. |

# 3 Transportation, Storage and Disposal

## 3.1 Transportation

Analyzer should be transported in package to any distance by any kind of transport excluding unsealed aircraft compartments and open decks. Analyzer should be protected against precipitations while transportation.

Transportation conditions:

1. ambient temperature from -40 to +50°C;
2. relative air humidity up to 100 % at 25°C;
3. presence of a dust or aggressive vapors in the air isn't allowed.

**Attention!**

During transportation of analyzer at the temperature below -20°C an electrochemical sensor supplied with analyzer must be transported separately at the temperature from -20 to +50°C.

Analyzer must be unpacked in dry and heated areas. If analyzer was transported at the temperature below 5°C it must be stored in these areas during 24 hours.

## 3.2 Storage

Analyzer should be stored in a packed state indoors under the following conditions:

4. ambient temperature from -40 to +50°C;
5. relative air humidity up to 98 % at 25°C;
6. presence of a dust or aggressive vapors in the air isn't allowed.

Storage near heaters isn't allowed.

**Attention!**

Electrochemical sensors supplied with analyzer must be stored separately at the temperature from 0 to +40°C. It is allowed to leave sensors in analyzers during the long-term storage subject to the required storage temperature range of the sensors.

## 3.3 Disposal

Analyzers do not contain harmful substances and components that pose a threat to human health and the environment during and after the end of life and disposal.

Disposal analyzer is carried out separately for groups of materials: plastic parts, metal parts and the housing fasteners.

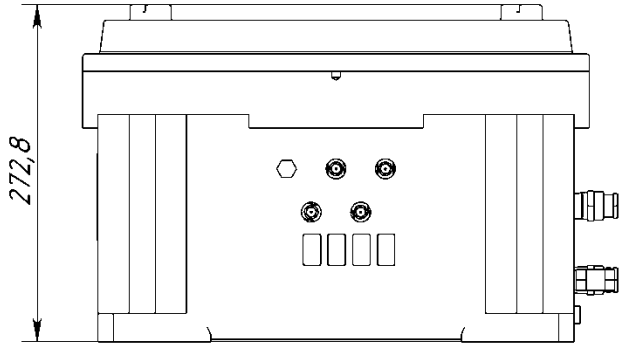
**Manufacturer**

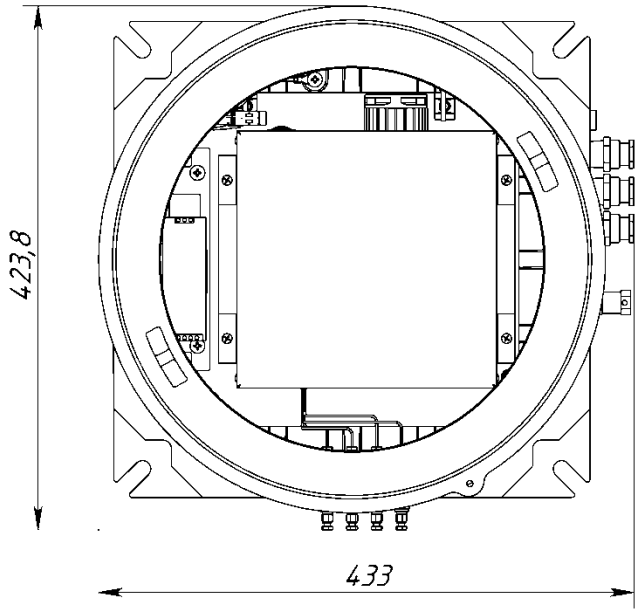
STF «BACS», Ltd. Samara

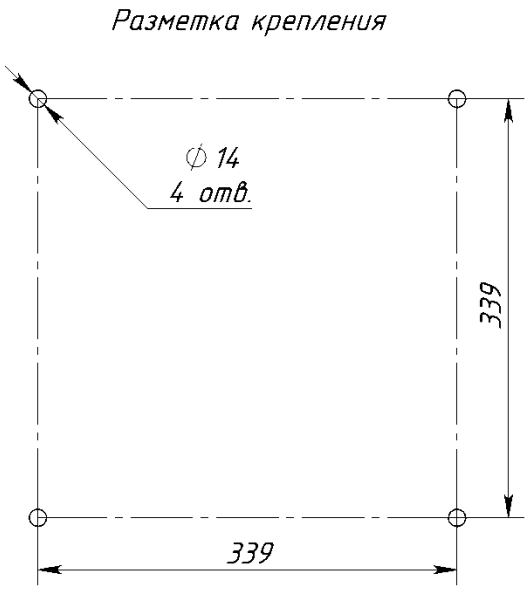
Address: 443022, Russian Federation, Samara, Kirova ave. 10

# APPENDIXES

## Appendix A. Dimensional drawing



# Appendix B. Electrical interfaces diagram.