LUMEX INSTRUMENTS CANADA
(0890278 B.C. Ltd)

RA-915M MERCURY ANALYZER

OPERATION MANUAL

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CE

2015

Read the instructions in this manual carefully before operating the RA-915M analyzer. Neither LUMEX INSTRUMENTS CANADA nor its representatives will accept any liability for the damage caused by non-observance of the requirements of this manual.

RA-915M MERCURY ANALYZER is subject to improvements and the information in this manual may not include the latest updates on the RA-915M MERCURY ANALYZER design.

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About this manual

This manual is designed to familiarize you with the principle of operation and structure of the RA-915M analyzer (hereinafter referred to as the «analyzer»), its design, performance characteristics and operating conditions. It contains information that will provide proper operation and comprehensive utilization of the analyzer's capabilities. Please take time to read the manual in order to attain the best results in operation and to gain the greatest benefit from your analyzer. This manual contains:

- List of important safety measures, warnings and precautions, which you should follow when operating with the analyzer.
- The purpose of the analyzer, its basic performance and analytical characteristics, and operating conditions.
- Brief description of the physical foundations and the principle of operation of the analyzer, and of its design.
- Functional controls of the analyzer, their purpose and operation.
- Procedures for preparation of the analyzer for operation in different configurations using appropriate operation modes.
- Procedures for handling the analyzer in all of the operation modes using the display and control unit.
- Brief description of procedures for analyzer operation using a PC.
- Procedures for analyzer maintenance.
- Instructions for troubleshooting.

Symbols used in this manual

Danger:

Used when failure to observe a safety precaution may result in a serious injury.

Warning:

Used when there is a danger of a minor injury or a serious damage to the analyzer if you do no follow the precautions.

Caution:

Used when there is a danger of a minor damage to the analyzer if you do no follow the precautions.

Used to indicate supplementary information or to call attention to recommendations which may simplify daily operation.

Safety guidelines

Important safety precautions

Read these rules completely before starting operation with analyzer.

- Carefully study all the sections of this operation manual, analyzer design and control functions.
- To avoid electrical shock, never work with the analyzer covers taken off.
- Do not put extraneous objects inside the analyzer through its ports.
- Do not allow the ingress of liquids on the case or inside the analyzer.
- Use only the power supply which is provided.
- Never use a defective power supply cable, do not put any objects on the power supply cable, and locate it in a manner to avoid a trip hazard.

- Do not try to repair the analyzer or adjust its optical units and electronic boards by yourself, except for cases stipulated in troubleshooting section (Appendix 1).
- Call an authorized agent or certified service engineer in the following cases:
  - If the analyzer does not operate properly or its parameters have noticeably deteriorated.
  - If the analyzer has fallen down or if its case is damaged.
  - If there has been ingress of any liquid inside the analyzer.
  - If you hear unusual sounds or sense unusual smell coming from the analyzer.
- Keep the analyzer at a minimum distance of 1 meter from heating devices and heat sources. Do not transport analyzer in the boot of your car.
- Do not forget to switch the analyzer off when the working day is over and to disconnect the power supply unit from the mains if the analyzer is not used for more than 6 hours.
- Never work without sorption and dust filters.
- The analyzer should be switched off before any maintenance operations.
- When measuring mercury concentration, it is necessary to follow instructions and documents stating safety regulations for operation in chemical laboratories and safety rules for operation with electric appliances.

Observe the following rules during any transportation of the device, as well as when performing measurements from a moving vehicle (car, helicopter, etc.):

- To avoid strong vibration effects, do not place the device on a hard surface (baggage compartment, floor of a vehicle, etc.).

- Place the device on shock-insulated surfaces (a seat, damping support, etc.).
- Secure the device on a working surface to prevent its fall or incidental contact with other objects.

Observe the following safety precautions during outdoor operation:

- Do not work in rainy or foggy weather and avoid precipitation ingress inside the analyzer.
- Do not work in dusty ambient air.
- Staff members permitted to operate the device are recommended to undergo training at the supplier’s premises or at a regional service centre.

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1 Introduction

1.1 General description

The RA-915M Analyzer is intended for measuring mercury vapour concentration in the ambient air and in the air of residential quarters and production areas as well as in natural gas and in factory smokestack emissions.

The analyzer can be used for on-stream measuring of mercury vapour concentration in the air both in a stationary mode and for continuous survey from vehicles (car, helicopter, boat).

The analyzer is a useful tool in industrial hygiene, ecological monitoring, technological process control and scientific research.

The analyzer and its attachments constitute the system, which enables the determination of mercury content in potable, natural and waste water samples, soils, foodstuff and feed stocks, biological samples, oil and its processing products in accordance with established techniques.

Read this manual carefully before starting operation with the analyzer.

1.2 Performance characteristics and specifications

Measuring range of the mercury vapour mass concentration in air (response time 30 s)*, ng/m^3	2 – 200000
Relative intrinsic error of measurement (δ_0), not more than, %	$\pm$ 20
Standard deviation of zero readings, ng/m^3, not more than	2**
Measurement repeatability (span) for the mercury vapour mass concentration of 100 ng/m^3 and higher, %, not more than	5
Drift of zero readings within 5 min, not more than, ng/m^3	2
Transitory time of analyzer readings, s, not more than	20
Analyzer warm-up time, min, not more than	20
Volume air flow rate of the analyzed air at the analyzer input, dm^3/min, not less than	10
Sorption coefficient of mercury vapour by the built-in sorption filter, not less than, %	98
Complementary error caused by the ambient temperature change within the operating range for each 10°C, not more than, %	$\pm 0.5\delta_0$
Complementary error caused by the ambient pressure change within the operating range for each 3.3 kPa is not more than, %	$\pm 0.2\delta_0$
Analyzer power supply:	
– built-in battery	12 V DC
– AC power source through external power supply unit (hereinafter referred to as PSU)	100…240 V AC, 50/60 Hz, 40 VA
Analyzer continuous operation with the built-in battery, h, not less than	8
Analyzer dimensions (LxWxH), not more than, mm	470x110x220
Weight, kg, not more than	7

* The measuring range starts at 20 ng/m^3 for the response time of 1 s.

** Response time is 1 s.

1.3 Operating conditions

Ambient air temperature, °C	1- 40
Ambient pressure, кPa	84.0-106.7
Relative humidity at 35°C, not more than, %	95
Sinusoidal vibrations in the frequency range:	
displacement amplitude (mm) at transition frequency (60 Hz) and below, not more than	0,35
acceleration amplitude at frequencies exceeding the transition frequency, m/s^2, not more than	49 (5g)
Content of unmeasured components in the analyzed gas mixture, mg/m^3, not more than:	
carbon monoxide (CO)	40
nitrogen monoxide (NO)	90
hydrogen sulphide (H_2S)	100
nitrogen dioxide (NO_2)	100
sulphur dioxide (SO_2)	10
ammonia (NH_3)	30
benzene (C_6H_6)	1

1.4 Analyzer design

The RA-915M Mercury Analyzer can be controlled either by the built-in display and control unit (hereinafter referred to as the control panel) or by the PC connected to the analyzer with the interface cable.

The components which constitute the basic delivery kit are shown in Table 1-1.

Table 1-1

№	Item	Quantity, pcs.	Catalogue code
1	RA-915M MERCURY ANALYZER	1	5-020-001
2	Power supply unit for AC power mains	1	5-024-003
3	Power cord	1	5-014-033
4	CD with software	1	5-022-001
5	Interface cable	1	5-024-038
Spares Kit:			
6	Sorption filter	1	5-024-028
7	Dust filter	1	5-024-029
8	Tool set	1	5-024-045
Accessories Kit:			
9	Analyzer transfer bag	1	5-024-026
10	Air intake hose	1	5-024-030
Documentation:			
11	Certificate of Quality	1	5-023-014
12	Operation Manual	1	5-023-007
13	Software User’s Manual	1	5-023-010
14	Short Guide (HIGH CONCENTRATION MODE)	1	5-023-002
15	Short Guide (ON STREAM MODE)	1	5-023-004
16	Short Guide (DATA LOGGER MODE)	1	5-023-006

1.5 Analyzer Description and Principle of Operation

1.5.1 General Principles of Operation

The RA-915M analyzer operation is based on differential Zeeman atomic absorption spectrometry using high frequency modulation of light polarization (ZAAS-HFM). For more details, refer to Annex A.

1.5.2 Description of Analyzer

The RA-915M analyzer can be operated either as a portable one with the use of the control panel or as a stationary laboratory device controlled by PC software.

The following marks are located on the right side of the analyzer:

- Analyzer name;
- Manufacturer’s trademark.

The nameplate with the following information is placed on the left-hand side of the analyzer:

- Manufacturer’s trademark;
- Analyzer name;
- Analyzer serial number;
- Operations conditions;
- Year of manufacture;
- Power supply ratings;
- Certification marks.

The upper panel of the analyzer contains the built-in display and control unit.

The analyzer panels are displayed in the figures Fig. 1-1 - Fig. 1-4.

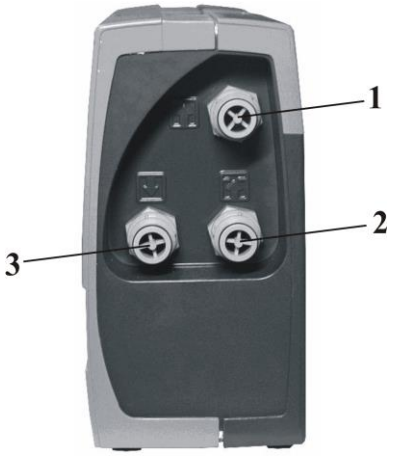


Fig. 1-1 - Front panel of the analyzer

1 - Inlet (marked with yellow) is used for determination of the mercury vapour content in the air (or gas) – labelled as ;

2 - Inlet (marked with blue) is intended for the air intake into the multi-path cell through the built-in sorption filter - labelled as ;

3 - Outlet of the multipath cell air flow – labelled as

Fig. 1-2 - Rear side of the analyzer

1 – Compartment for the single-path analytical cell (single-path cell is used for the analyzer validation, analysis of water, natural gas etc.);

2 – Slot for a holder of the external optical units of the RP-91C and PYRO-915+ attachments;

3 – Power supply cable connector.

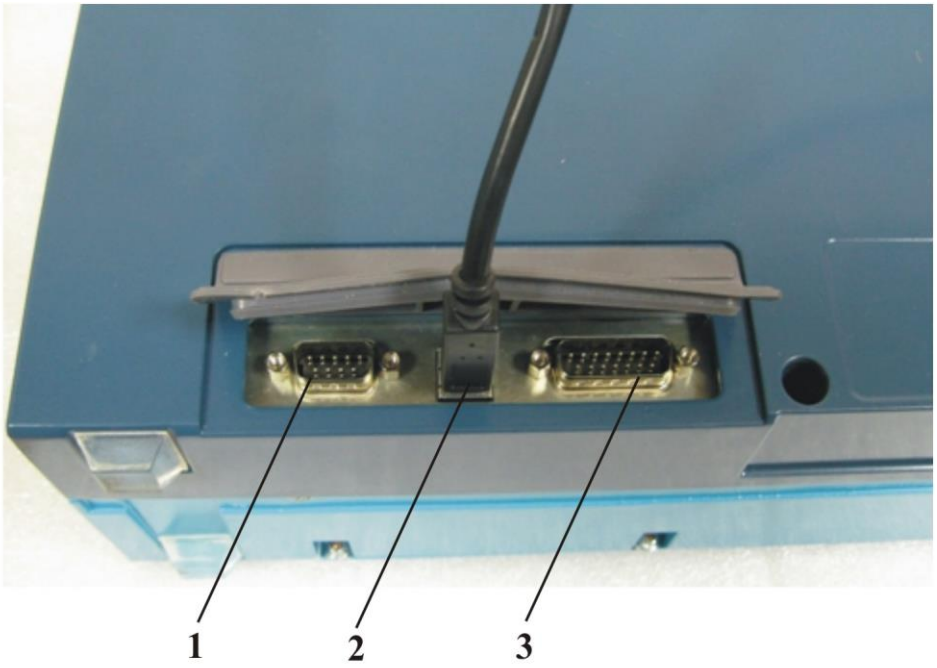


Fig. 1-3 - Left-hand side panel of the analyzer

1 – PC Interface cable connector, RS-232 standard;

2 – PC Interface cable connector, USB standard;

3 – Service connector.

Fig. 1-4 - Right-hand side panel of the analyzer

1 – Slot for mounting the analytical cell external optical units of the RP-91C and PYRO-915+ attachments;

2 – Removable decoration cover of the sorption and dust filters.

1.5.3 Display and Control Unit

The display and control unit of the analyzer is shown in Fig. 1-5.

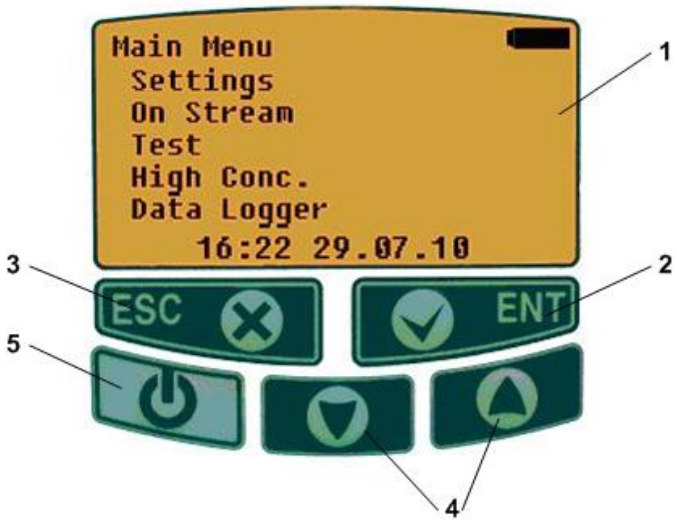


Fig. 1-5 - Display and control unit

1 – Display panel for the visualization of signal indications, parameters and operating mode;

2 – **Ent** (Enter) button to switch to the lower menu level;

3 – **Esc** (Escape) button t o return on the upper menu level;

4 – ↑, ↓ buttons to navigate through the menu at a particular level;

5 – **On/Off** button.

2 Analyzer operation

2.1 Pre-operational Procedures and Setup

2.1.1 Unpacking and Installation

Unpack the analyzer in the following order:

- Use a sharp tool to cut the packing straps and carefully open the transportation box;
- Remove the foam frame to uncover the analyzer, documentation and analyzer accessories;
- Take the analyzer out of the transportation box and put it on a table;
- Take out the documentation;
- Take out the accessories.

Make sure that the package with the analyzer is stored indoors for at least ten hours after the transportation at temperatures below 0°C and then start unpacking the analyzer.

For transportation the analyzer should be packed in the reverse order.

Before starting the operation with the analyzer make sure that there are no external damages of the analyzer and its accessories. Check if the delivery set is complete in accordance with the enclosed packing list.

In the case of any inconsistency please contact your Supplier

2.1.2 Analyzer installation and starting up

Place the analyzer horizontally on a working surface so that the display and control unit is on the top.

Switch on the analyzer by pressing the **On/Off** button (pos.5, Fig. 1-5) and hold it down for 1-2 seconds (to switch the analyzer off press the **On/Off** button and **hold it down for 4-5 seconds**). The splash screen that contains the model name, the manufacturer's name, the serial number, software versions and the current date and time will appear on the display (Fig. 2-1).

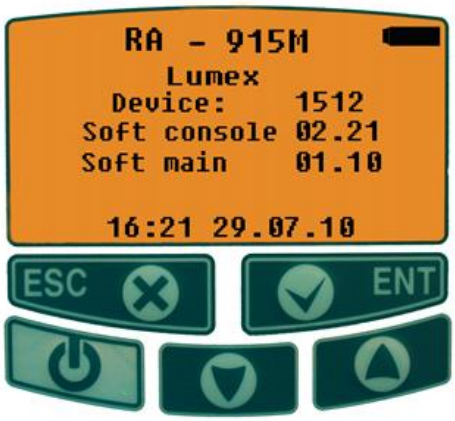


Fig. 2-1 - Splash screen

Check the battery charge level in case of the stand-alone use. The indicator ▬ located in the right top corner of the display shows the current charge level of the battery. If necessary, charge the battery as described in section 2.1.3.

Press the **Ent** button to enter the ***Main menu*** (see Fig. 2-2).

⇨ If you only need to recharge the battery and/or to download the monitoring data from the analyzer to the computer, it is recommended not to ignite the lamp to extend its lifetime.

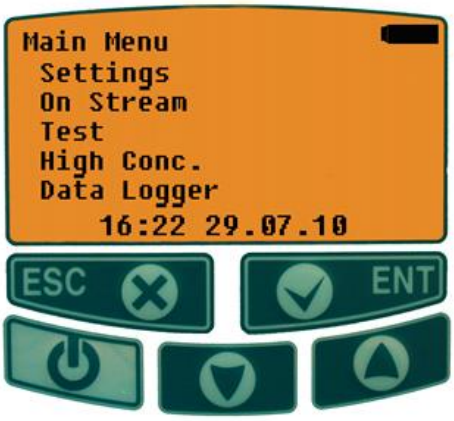


Fig. 2-2 - Main menu window

Wait at least 20 minutes for the completion of the instrument warm-up before starting measurements.

If the analyzer does not respond to any action, press the **On/Off** button (pos.5, Fig. 1-5) and the **Esc** button (pos.3, Fig. 1-5) simultaneously to restart the analyzer. To restart the analyzer with 06.25 or a higher version of the console software, press the **On/Off** button (pos.5, Fig. 1-5) and the **Ent** button (pos.2, Fig. 1-5) simultaneously.

2.1.3 Charging the Battery

The battery is being charged when the analyzer is connected to the AC power mains 90…240V AC, 48…62 Hz via the power supply unit from the delivery set.

If you need only to charge the analyzer battery without performing any measurements, it is not recommended to enter the ***Main menu*** (ref. 2.1.2).

Warning:

Make sure that the mains supply voltage indicated on the analyzer nameplate at the left-hand panel of the analyzer corresponds to the mains supply voltage.

The total time of charging a flat battery is 5 hours.

Longer charging time does not damage the battery.

The fully charged battery ensures the continuous operation of the analyzer for not less than 8 hours.

Caution:

Long-term (more than 10 days) storage of a flat battery may damage it and is not allowed.

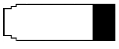
You can check the battery charge level using the indicator in the top right corner of the control panel:

 - The battery is charged at 100% of the resource;

 - The battery is charged at 80% of the resource;

 - The battery is charged at 60% of the resource;

 - The battery is charged at 40% of the resource;

 - The battery is charged at 20% of the resource;

 - Low battery, charging it is necessary.

If the analyzer is connected to the AC mains via the external power supply unit, the  indicator is displayed on the control panel.

2.1.4 Setting Parameters

To set the operation parameters, select the ***Settings menu*** item from the ***Main menu*** (Fig. 2-2) by using the navigation buttons (↑ and ↓**)** and press the **Ent** button. The ***Settings menu*** window will appear on the display (Fig. 2-3).

Fig. 2-3 – Settings menu window

In this menu, you can set and modify the following operation parameters and view options:

- **Select Language**

To choose the display language, select the **Select Language** menu item from the ***Settings menu*** by using the ↑ and ↓ navigation buttons and press the **Ent** button.

The ***Select Language*** window will appear. Russian and English are available for selection.

Use the ↑, and ↓ navigation buttons to pick the required language and press the **Ent** button.

The ***Main menu*** window will be displayed in the selected language.

- **Time/Date**

⇨ It is crucial to set the time and data correctly especially in the *Monitoring* mode as the measurement results are stored along with the time and date stamp.

To set the date and time, select the **Time/Date** menu item by using the ↑ and ↓ navigation buttons and press the **Ent** button. The ***Time/Date*** dialog will be displayed.

Use the **Ent** button to select a time/date parameter (hour, minute, date) and the ↑ and ↓ navigation buttons to modify it.

Press the **Esc** button to store the set values. The ***Setting Menu*** window will be displayed (Fig. 2-3).

- **Sound**

To switch on/off the sound, select the **Sound** menu item by using the ↑ and ↓ navigation buttons and press the **Ent** button. The ***Sound*** dialog will be displayed.

Use the ↑ and ↓ buttons to select **On/Off** mode.

Press the **Esc** button to store the chosen option and to return to the ***Settings Menu*** (Fig. 2-3).

If the sound is on, the analyzer will produce a sound when you press any button on the control panel or if some events occur such as excess of mercury concentration over the preset value or a complete discharge of the battery.

- **STP normal.**

This parameter is to enable/disable recalculation (“normalization”) of the measured mercury vapour concentration for a normal (standard) temperature and pressure (20°C and 101.3 kPa or 760 mm Hg by default). If it is set **ON**, the data will be normalized. Otherwise, they remain unchanged.

To switch on/off the normalization, select the **Normalized STP** item, choose the option (**ON** or **OFF**) you need by the ↑ and ↓ navigation buttons and press the **Ent** button. The ***Settings menu*** window (Fig. 2-3) will appear on the display and the current status (**ON** or **OFF**) will be shown in the line of the **Normalized STP** menu item.

- **Parameters**

Select the **Parameters** menu item from the ***Settings menu*** by using the ↑ and ↓ navigation buttons and press the **Ent** button.

The ***Parameters menu*** window will be displayed (Fig. 2-4).

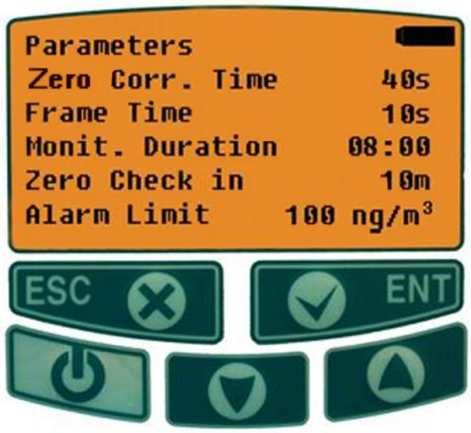


Fig. 2-4 - Parameters Menu

In this menu you can set a value for a list of parameters:

- **Zero Corr. Time** is the period of time (t_{zero}) in the range from 40 to 255 s (default value is 40 s) within which the signal corresponding to the zero mercury vapour concentration in the analytical cell will be measured;
- **Frame time** is the period of time in the range from 1 to 600 s (default value is 10 s) over which the signal is averaged;
- **Monit. Duration** is the time of measurement in the *Monitoring* mode (default value is 30 min, working range is form 5 min to 99 h 59 min);
- **Zero Check in** is the period of time between two consequent checks of the zero signal in the *Monitoring* mode (default value is 10 min, working range is 5...30 min);
- **Alarm limit** is the mercury concentration upon exceeding of which the blinking **"A"** symbol appears on the screen and a sound alert is produced when the analyzer is operating in the *Continuous* mode (default value is 100 ng/m^3, accessible range is 1 to 50000 ng/m^3).

To modify a parameter, proceed as follows:

- Use the ↑ and ↓ menu navigation buttons to select the parameter that needs to be changed and press the **Ent** button. The selected parameter value starts to blink;

- Use the ↑ and ↓ navigation buttons to set the required value and press the **Ent** button;
- When the required values of all parameters are set, press the **Esc** button. The ***Save parameters*** dialog will be displayed over the ***Parameters menu*** window (Fig. 2-5). Three options are available: **Save** – to save all changes, **Cancel** – to reject all changes, **Default** – to restore default parameters.

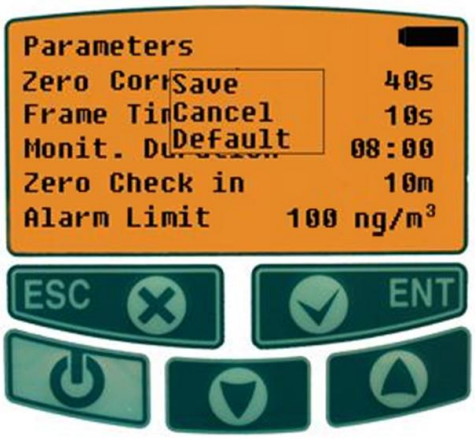


Fig. 2-5 – Save parameters dialog

To execute the required command, select it with the ↑ and ↓ buttons and press the **Ent** button. The desired action will be carried out and the ***Settings Menu*** window (Fig. 2-3) will appear.

2.1.5 Checking Analyzer Serviceability

To check the analyzer serviceability, select the *Test* mode in the ***Main menu*** (Fig. 2-2) by using the ↑ and ↓ navigation buttons and press the **Ent** button.

Upon pressing the **Ent** button, the Analyzer starts self-testing according to the standard algorithm. After about 30 s the *D* value will appear in the left bottom corner of the display (Fig. 2-6).

If the absolute value of *D* is less than 20% (or less than 30% at the ambient temperature out of the 15 to 25°C range), the analyzer is ready for operation. If the absolute value of *D* goes beyond these norms, repeat the test procedure. If the absolute value of *D* exceeds the norms at the repeated check, the analyzer readings may be not adequate.

Press the **Esc** button to return to the ***Main menu*** window (Fig. 2-2).

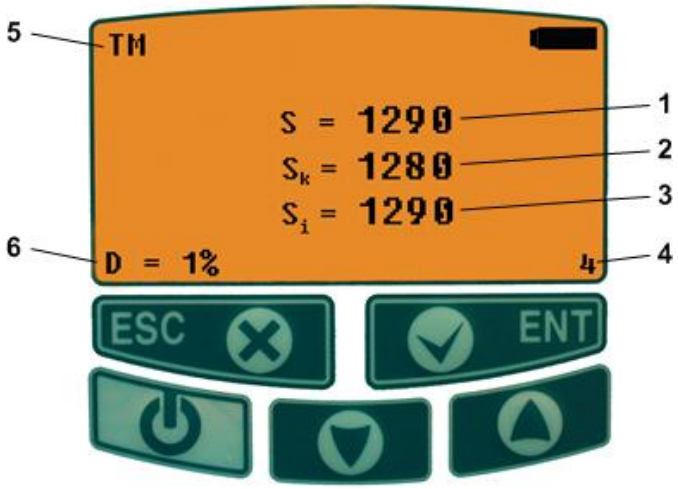


Fig. 2-6 - Test mode window

1 – Current value **(S)**, i.e. the measured value of the mercury vapour concentration in the test cell (displayed every second in conventional units).

2 – Check value **(S_k)**, i.e. the conventional true value for the mercury vapour concentration in the test cell.

3 – Mean value **(S_i)**, i.e. the mean mercury vapour concentration value over the frame time, in the conventional units.

4 – Frame time countdown, in seconds.

5 – Name of the measurement mode. **TM** stands for the Test Mode.

6 - **D** - It is the relative deviation of the measured mercury vapour concentration in the test cell from the check value: **$D= 100*(S_i- S_k)/S_k$.**

2.2 Analyzer Operation

2.2.1 Operation in the On Stream Mode

The *On Stream* mode is used for the measurement of mercury vapour concentration in the range of 20 to 20000 ng/m^3, the range of indications ranging from 0 to 50000 ng/m^3.

Select the *On stream* mode from the ***Main menu*** (Fig. 2-2) by the ↑ and ↓ navigation buttons and press the **Ent** button. The zero check procedure, duration of which (t_{zero}) was set in the ***Parameters menu*** (Fig. 2-4), starts. Immediately after the zero check procedure is completed, the measurement of mercury vapour concentration in the multi-path cell occurs. An example of the measurements results is shown in Fig. 2-7.

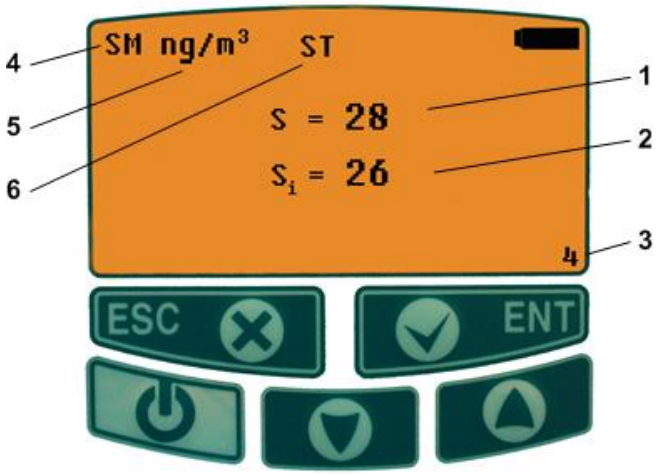


Fig. 2-7 - On Stream mode window

1 – Current value **(S)** is the current mercury vapour concentration in the pumped air flow (displayed every second).

2 – Mean value **(S_i)** is the mean value of the mercury vapour concentration over the frame time (displayed once per frame time) (ref. 2.1.4, Fig. 2-3).

3 – Frame time countdown, in seconds.

4 – Name of the measurement mode, **SM** stands for On Stream Mode

5 – Measurement units of the mercury vapour concentration (**ng/m^3**): 1 ng/m^3 = 0,001 μg/m^3 = 0,000001 mg/m^3.

6 – **ST** is displayed if the automatic procedure of data normalization is set on (ref. 2.1.4, Fig. 2-3).

Upon pressing the **Ent** button in the *On Stream* mode the analyzer switches over to the *Protocol* mode (Fig. 2-8), in which three consecutive mean values of the mercury vapour concentration and the resulting mean value are displayed.

This mode is useful if the measurements results are recorded manually in a logbook without data logging.

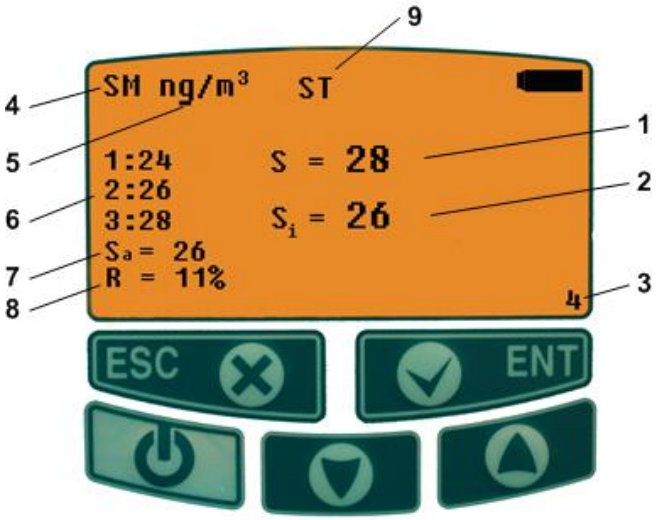


Fig. 2-8 - Protocol mode window

1 – Current value **(S_i)** is the current of the mercury vapour concentration in the air (displayed at a frequency of 1 Hz).

2 – Mean value **(S_i)** is the mean value of the mercury vapour concentration over the frame time (displayed once per frame time) (ref. 2.1.4, Fig. 2-4).

3 - Frame time countdown, in seconds.

4 - Name of the measurement mode: **SM** stands for On Stream Mode.

5 – Measurement units of the mercury vapour concentration (**ng/m^3**): 1 ng/m^3 = 0,001 μg/m^3 = 0,000001 mg/m^3.

6 – Three consecutive mean values of the mercury vapour concentrations.

7 – Resulting value (**S_a**). The resulting value is the arithmetic mean of three consecutive mean values **S_i**. If the **S_a** value is less than 5 ng/m^3, the S_a<5 message will be displayed. If **S_a** is over the upper limit of indication, which can be set using external software; the default value is 50000 ng/m^3, the message **S_a** >50000 is displayed (true for the upper level value by default).

8 - Range **(R, %)**. It is the relative difference between the maximum and minimum values of mercury vapour concentration taken from the three latest consecutive measurements:

$$R = \frac{S_{i\,max} - S_{i\,min}}{S_a} \cdot 100$$

9 – **ST** is displayed if the automatic procedure of data normalization is set on (ref. 2.1.4, Fig. 2-3).

To exit the *Protocol* mode or *On Stream* mode, press the **Esc** button. The ***Main menu*** window appears on the display (Fig. 2-2).

Additional indications and operations in the *On Stream* and *Protocol* modes are available*:*

- Upon pressing the ↓ button, the airflow pump stops if it is operating and «0x» indicator appears on the display. *Vice versa*, upon pressing the ↑ button, the airflow pump starts operating if it is out of operation and «0x» indicator disappears;
- The “Low radiation” sign («•») appears on the display at low intensities of light which means that the intensity of light is not sufficient for correct operating (ref. 4);
- The «**A**» sign appears on the display if the measured mercury vapour concentration exceeds the specified upper limit value which can be set in the ***Parameters menu*** (ref.2.1.4, Fig. 2-4).

When the long-term continuous measurements are carried out, it is recommended to perform the zero check procedure at least once in 20-30 minutes. To do that, switch the analyzer over to the *On Stream* operation mode.

It is also recommended to carry out the zero check procedure in the case of abrupt ambient air temperature change (more than 5°C, e.g. when transferring the analyzer from a heated to a non-heated room).

2.2.2 Operation in the “High Concentration” Mode

The mode *High Concentration* is used for the evaluation of mercury content in the ambient air at a concentration level of 10 to 2000 μg/m^3.

The measurements are conducted in the open cell compartment for the single-path cell with the air pump turned off. The air exchange in the

compartment is induced by movement of the analyzer. To operate in this mode:

- Put the analyzer for zero check in the area where the concentration of mercury does not exceed 0.5 μg/m^3;
- Remove the analyzer from the bag and open the door of the single-path cell compartment (pos.1, Fig. 1-2);
- Select the *High Concentration* mode In the ***Main menu*** using the ↑, ↓ buttons and press the **Ent** button. The analyzer automatically started the zero check procedure duration of which was set in the ***Parameters menu*** (ref. 2.1.4, Fig. 2-4);
- After the zero check is completed, transfer the analyzer to the point of interest and read the mercury concentration that is displayed.

An example of the measurements results is shown in Fig. 2-9.

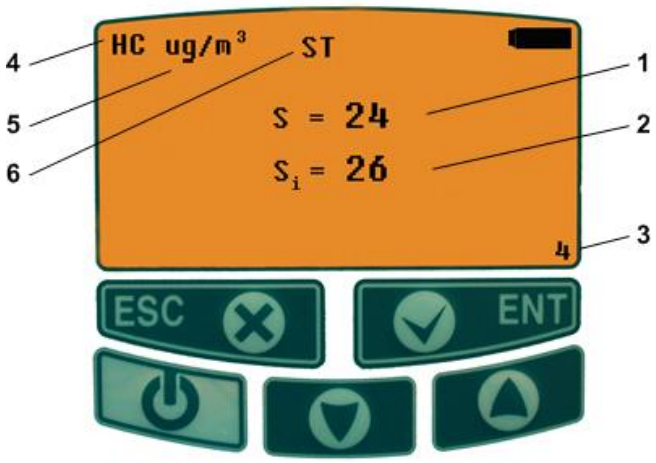


Fig. 2-9 – High Concentration mode window

1 – Current value **(S_i)** is the current concentration of mercury vapour in the air (displayed every second).

2 – Average value **(S_i)** is the average concentration of mercury vapour over the frame time (displayed once per frame time) (ref. 2.1.4, Fig. 2-4).

3 - Frame time countdown, in seconds.

4 - Name of the measurement mode: **HC** stands for High Concentration.

5 – Measurement units of the mercury vapour concentration (**μg/m^3**): 1 μg/m^3 = 1000 ng/m^3 = 0,001 mg/m^3.

6 – ST is displayed if the automatic procedure of data normalization is set on (ref. 2.1.4, Fig. 2-3).

Upon pressing the **Ent** button in the *High Concentration* mode, the *High Concentration Protocol* mode appears (Fig. 2-10), in which three consecutive mean values of the mercury vapour concentrations and the resulting mean value are displayed.

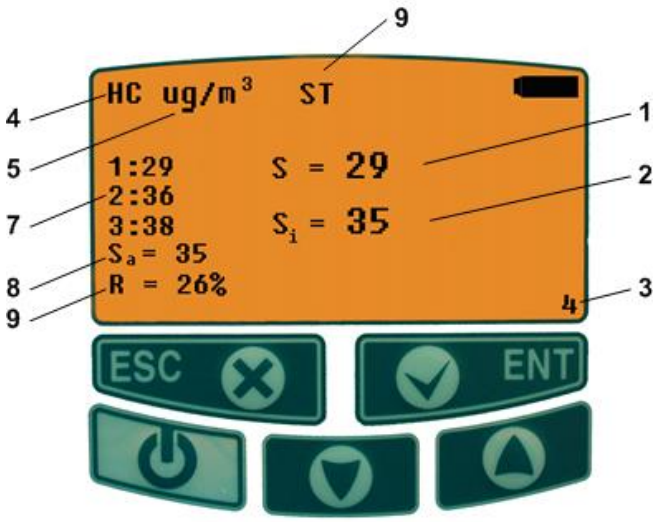


Fig. 2-10 - High Concentration Protocol Mode display

1 – Current value **(S_i)** is the current mercury vapour concentration in the air (displayed every second).

2 – Average value **(S_i)** is the average mercury vapour concentration over the frame time (displayed once per frame time) (ref. 2.1.4, Fig. 2-4).

3 - Frame time countdown, in seconds.

4 - Name of the measurement mode: **HC** stands for High Concentration.

5 – Measurement units of the mercury vapour concentration (**μg/m^3**): 1 μg/m^3 = 1000 ng/m^3 = 0,001 mg/m^3.

6 – Three consecutive mean values of the mercury vapour concentrations.

7 – Resulting value **(S_a)**. Resulting averaged value over three mercury vapour concentrations on the display. If the S_a value is less than 0.5 μg/m^3, the S_a<0,5 message will be displayed. If S_a is over the upper level (the upper level value can be set using external software, the default value is 2000 μg/m^3), the message S_a >2000 is displayed (example for the upper level value by default).

8 - Range **(R, %)**. It is the relative difference between the maximum and minimum values of mercury vapour concentration taken from the three latest measurements (ref.6):

$$R = \frac{S_{i\,max} - S_{i\,min}}{S_a} \cdot 100$$

9 – **ST** is displayed if the automatic procedure of data normalization is set on (ref. 2.1.4, Fig. 2-3).

This mode is useful if the measurements results are recorded manually in a logbook without data logging.

To exit the *Protocol* mode or *High Concentration* mode, press the **Esc** button. The ***Main menu*** window appears on the display (Fig. 2-2).

If the “Low radiation” sign («•») appears on the display signalling the low level of light intensity, consult the Troubleshooting section.

When long-term continuous measurements are carried out, it is recommended to perform the zero check procedure at least once in 20-30 minutes. To do this, transfer the analyzer in the area where the mercury concentration does not exceed 0.5 μg/m^3 and carry out the zero check procedure (exit and re-enter the *High Concentration* mode**).**

It is also recommended to carry out the zero check procedure in the case of abrupt ambient air temperature change (more than 5°C, e.g. when transferring the analyzer from a heated to a non-heated room).

Caution:

In contrast to the *On Stream* **Mode the zero check in the** *High Concentration* **Mode is conducted in the compartment of the single-path cell. Therefore, during the zero check analyzer must be performed in the area where the mercury vapour concentration is below 0.5 μg/m^3.**

2.2.3 Operation in the Monitoring Mode

Monitoring mode is intended for the measurement of mercury concentration in the air using multi-path cell with periodical zero check and data logging.

In some dialogs, the *Monitoring* mode is designated as Data Logger (ref. Fig. 2-2, Fig. 2-11).

The data logger has the capacity of data storage for 122 h of measurement with 10 s averaging. With the maximum accumulation period of 600 s the data storage capacity covers 7330 h (305 days) of continuous operation. This mode consists of a set of measurements of mercury vapour concentration interrupted by zero checks on a regular basis.

It is recommended to set the averaging interval to at least 10 seconds and clean the data logger memory if necessary.

To operate in the *Monitoring* mode:

- Select the *Monitoring* mode with the ↑, ↓ navigation buttons in the ***Main menu*** window (Fig. 2-2) and press the **Ent** button. The initial screen of the *Monitoring* mode will be displayed (Fig. 2-11) in which the **Monit. duration** and **Available** time items are for reference. The monitoring duration and the interval between two consecutive zero checks should be set in the ***Parameters menu*** (Fig. 2-4) beforehand. If the data logger memory is full (available time is 0), the message «**Not enough memory. Press Esc**» will be displayed.
- To clear the data logger memory, select the **Clear memory** item using the ↑, ↓ buttons and press the **Ent** button. After an affirmative reply to the additional alert, the data logger memory will be cleared without the possibility to recover the information.

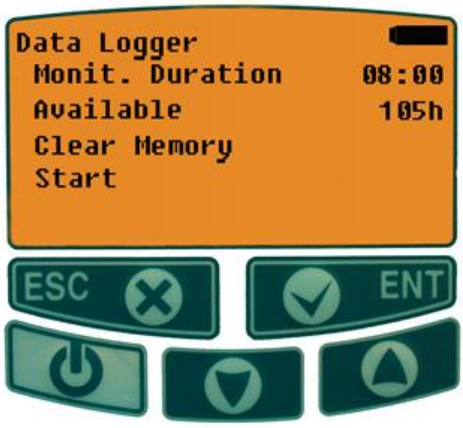


Fig. 2-11 – Initial screen of the Monitoring mode

- Select the **Start** option with the ↑, ↓ navigation buttons and press the **Ent** button to launch the measurements.

The analyzer automatically starts operating with the zero check procedure duration of which should be set in the ***Parameters menu*** (ref. 2.1.4, Fig. 2-4). After the zero check procedure is completed, the measurement of

mercury vapour concentration starts. The zero check is repeated periodically with an interval set in the ***Parameters menu*** (ref. 2.1.4, Fig. 2-4).

Before the completion of the monitoring cycle (i.e. after the monitoring time set in the ***Parameters menu*** (ref. 2.1.4, Fig. 2-4) has elapsed), the final zero check procedure is always carried out. The «**Monitoring completed**» message will be displayed. Press any button except for the **On/Off** one to display the initial screen of the *Monitoring* mode. If during the measurement the data logger memory becomes overflowed, the «**Monitoring completed**» message will be displayed.

An example of the measurements results is shown at the Fig. 2-12.

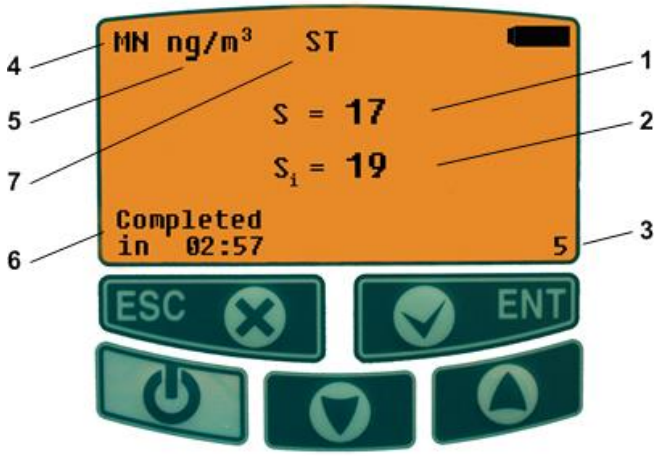


Fig. 2-12 - Monitoring mode display

1 – **Current value (S)** is the current mercury vapour concentration in the air (displayed every second).

2 – **Average value (S_i)** is the average concentration of mercury vapour over the frame time (displayed once per frame time) (ref. 2.1.4, Fig. 2-4).

3 - Frame time countdown, in seconds.

4 - Name of the measurement mode: **MN** stands for Monitoring Mode.

5 – Measurement units of the mercury vapour concentration (**ng/m^3**): 1 ng/m^3 = 0,001 µg/m^3 = 0,000001 mg/m^3.

6 – **Completed in** is the time remaining to the termination of the measurements.

7 – **ST** is displayed if the automatic procedure of data normalization is set (ref. 2.1.4, Fig. 2-3).

To download and treat the data stored in the data logger memory, use the RA-915M data logger software.

3 Analyzer Maintenance

The analyzer maintenance includes the following:

- Daily inspection;
- Quarterly preventive maintenance.

Daily inspection includes external examination of the analyzer (ref. 2.1.1) and the analyzer serviceability check-up (ref. section 2.1.5).

Quarterly preventive maintenance includes the following procedures:

- Inspection of the housing panels fastenings;
- Cables inspection;
- Replacement of the built-in sorption filter (Fig. 3-1) which should be carried out if the analyzer has been operated for about 500 hours in the *On Stream* mode, but not less than once per year.

Fig. 3-1 - Location of the sorption and dust filters of RA-915M analyzer

1- Sorption filter; **2**- Sorption (zero) filter cover; **3**- Dust filter; **4**- Dust filter cover.

4 Troubleshooting

The RA-915M Analyzer should be repaired at an authorized service centre or by the manufacturer.

Refer to Table 4-1 for possible causes of minor malfunction and find tips how to deal with them. Other cases of and malfunction please advise your Supplier or the Manufacturer and follow the instruction received.

Table 4-1

Fault symptom	Possible cause	Remedial measure
Some segments of the display or the display as a whole go out	Battery is discharged	Connect the external PSU to recharge the battery
In the *Test* mode, the relative deviation D is more than 20%	The ambient temperature is out of the range (20±5)°C	Perform the test at a temperature within the range (20±5)°C or take into account the complementary error
The "**Lamp is not ignited**" message is displayed upon entering the ***Main menu*** window	1. Lamp ignition failure 2. No photomultiplier signal	Check the single-path cell compartment, and remove the cell (if it is there) and repeat the ignition
"Low radiation" sign («•») is displayed on the screen or a sound (if enabled) is produced	1. No photomultiplier signal 2. Optical switch is in a wrong position	Check the single-path cell compartment, and remove the cell (if it is there). If the sign does not disappear, restart the analyzer
The analyzer does not respond to pressing any button	Hardware bust	Press simultaneously the **ON/OFF** button (pos.5, Fig. 1-5) and the **Esc** button (pos.3, Fig. 1-5) to restart the analyzer

5 Analyzer Storage and Transportation

The analyzer battery should be fully charged before the storage

Only the analyzer which is packed according to the requirements shown in 2.1.1 can be transported.

The analyzer may be transported by any kind of transportation without the limitations in speed and distance under the following conditions:

- Ambient air temperature from minus 50 to 50°C
- Relative humidity up to 100% at 25°C.

Placing and fastening of boxes with the analyzers on transportation vehicles should guarantee the steady position throughout the delivery, lack of displacements and instrument shocks. Instructions given by cargo signs should be followed at all stages of the delivery from the manufacturer to the customer.

Analyzer storage conditions within the transportation box:

- Ambient air temperature from 5 to 40°C
- Relative humidity not more than to 80% at 25°C.

Should other conditions be applied, they must be specified in the contract for the supply.

The content of dust, fumes of acids and alkalis and other corrosion-active agents shall not exceed the content of those for laboratories.

During the storage period, the analyzer should be placed so that a distance to the walls of the room should be not less than 0.1 m. Distance to heating devices should be not less than 0.5 m.

6 Warranty

The Manufacturer warrants each analyzer complies with the Specification given in this manual if the customer observes the rules of analyzer operation, transportation and storage conditions established by this Operation manual.

For more information please refer to Certificate of Quality B0100-00-00-00-00 CQ.

Annex A
(informative)
Physical Foundation and Principle of Operation

The RA-915M analyzer operation is based on differential Zeeman atomic absorption spectrometry using high frequency modulation of light polarization (ZAAS-HFM).

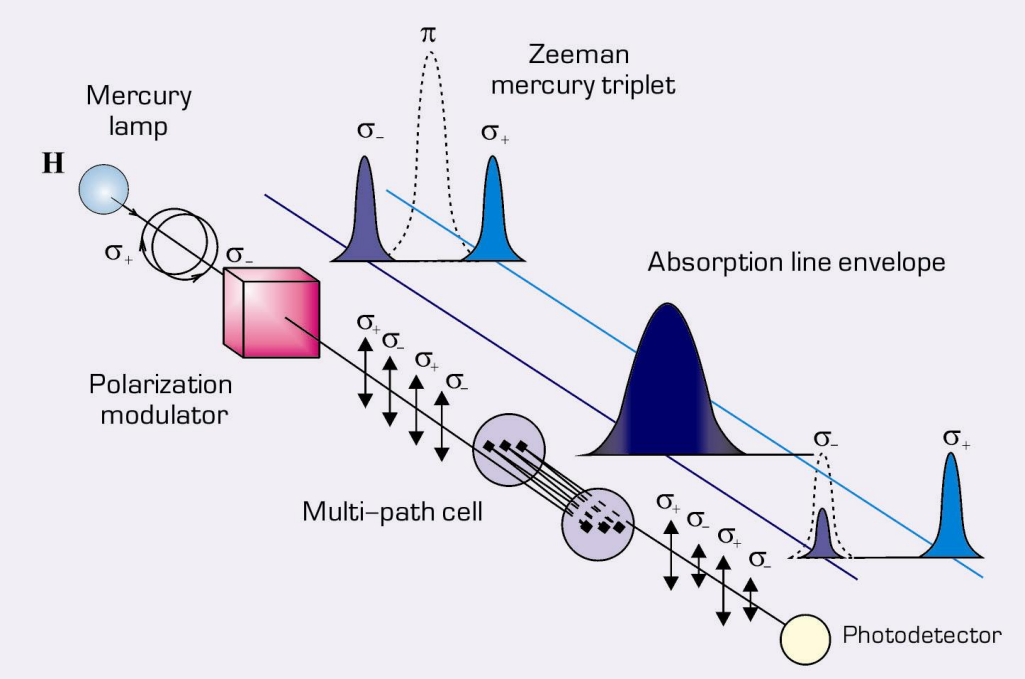


Fig.A-1 - Principle of operation of the RA-915M mercury analyzer

The radiation source (a mercury lamp) is placed in permanent magnetic field H. The mercury resonance line λ=254 nm is split into three polarized Zeeman components (π, σ_+ and σ_- respectively). When radiation propagates along the direction of the magnetic field, only the radiation of the σ-components one of these falling within the absorption line profile and another one lying outside reaches the photo detector. When mercury vapour is absent in the analytical cell, the radiation intensities of both σ- components are equal. When mercury atoms appear in the cell, the difference between the intensities of the σ-components increases as the mercury vapour concentration grows.

The σ-components are separated by the polarization modulator. The spectral shift of the σ-components is significantly smaller than the widths of molecular absorption bands and scattering spectra, hence the background absorption by interfering components does not affect analyzer's readings. A multi-path cell with an effective length about 10 m is used to enhance the sensitivity of analysis.

The block diagram of the analyzer is presented in Fig.A-2, where:

1 - Mercury EDL lamp,

2 - Polarization modulator,

3 - Test cell,

4 - Multi-path cell,

5 - Optical bridge with the automatic channel switch,

6 - Single-path cell compartment,

7 - Photo detector,

8 - Removable optical unit of analytical external cell (a part of the RP-91C or Pyro-915+ attachment),

9 - High-frequency generator,

10 - Gas flow commutation unit,

11 - Mercury absorption filter,

12 - Air pump of the multi-path cell,

13 - Electronic signal-processing unit,

14 - Display and control unit,

15 – PC.

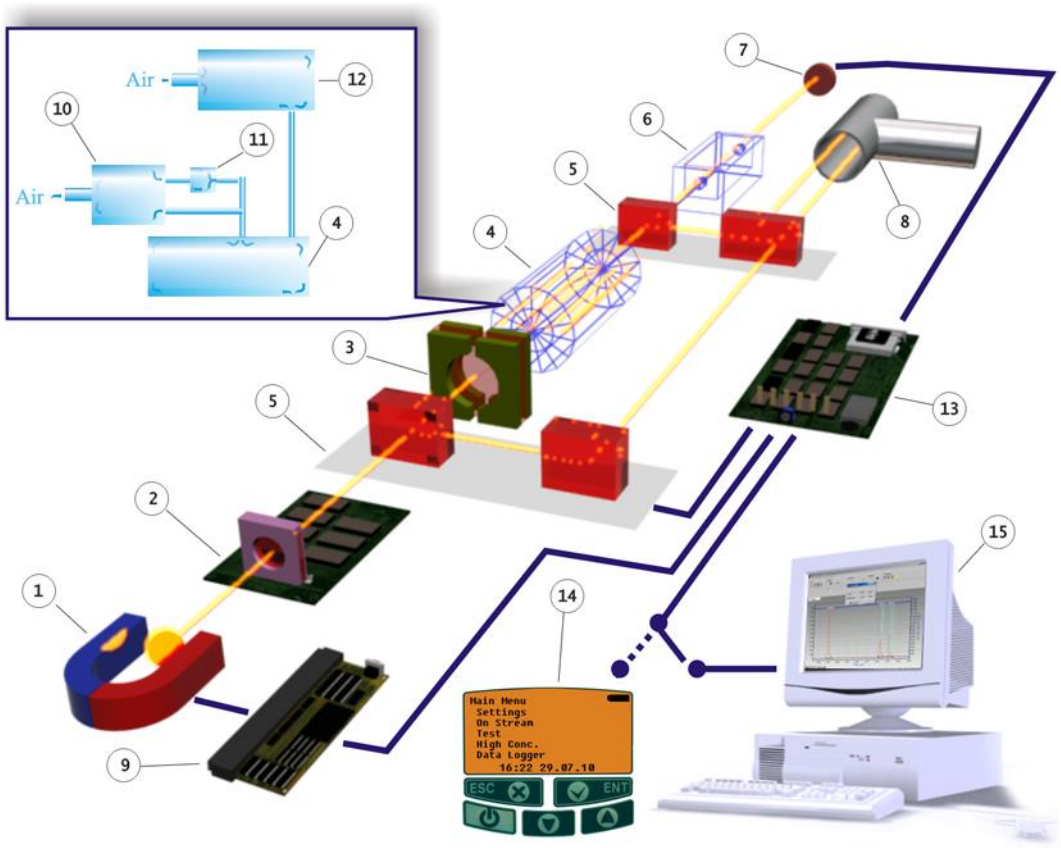


Fig.A-2 - Block diagram of the RA-915M mercury analyzer

Mercury EDL lamp (1), which is placed in the gap between the poles of the magnet, is excited by the high frequency generator (9). The light successively passes through the polarization modulator (2) to the optical bridge (5), which automatically switches the light beam direction depending on the selected operation mode. Three positions of the optical bridge are available. In the «*Multi-path cell*» position the radiation goes through the test cell (3) (if it is inserted into the light path in the ***Test*** mode), multi-path cell (4), single-path cell compartment (6) and is finally detected by photo detector (7). In the «*Single-path cell*» position the light beam passes only through the single-path cell compartment before reaching the photo detector. In the «*External cell*» position the radiation passes through the removable optical unit of the external analytical cell (8), single-path cell compartment and arrives at the photo detector.

The photo detector signal arrives at electronic signal-processing unit (13), where the signal is separated at the modulation frequency and the analytical signal is formed. After that the information is displayed on the screen of the display unit (14) or to a PC (15).