RA-915+ MERCURY ANALYZER

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About this manual

This manual is designed to familiarize you with the principle of operation and structure of the RA-915+ 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.
- Reference data for correction of results obtained during operation in different modes, as well as instructions for troubleshooting.

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.
- Charge the battery on a timely basis. Store the unit with the battery fully charged.
- 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 a liquid has gotten 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 trunk 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 absorption 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.

Operating personnel should participate in training at OhioLumex Co., Inc. premises or at a regional service center.

Note symbols

Cautions. *Pay attention to these in order to avoid damage of equipment.*

Notes. *They contain useful information, which will make the operation with the device easier.*

Contents

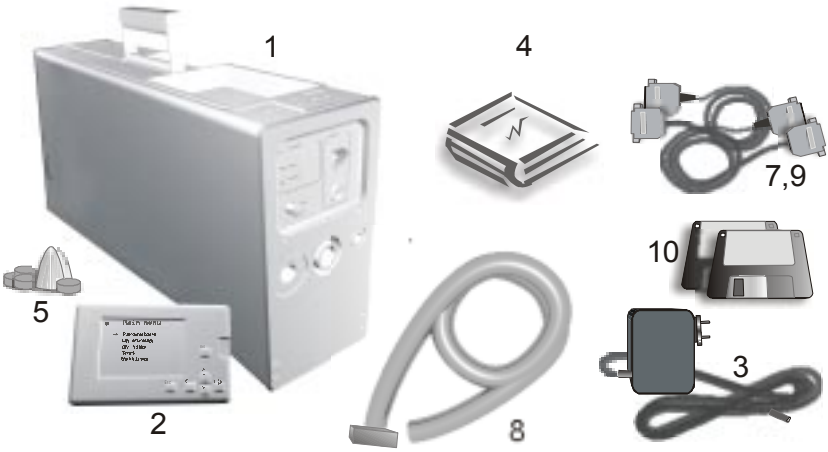
Introduction

Our compliments on the acquisition of the RA-915+ mercury analyzer. The advanced technologies implemented in the analyzer's production ensure their extraordinary reliability. The RA-915+ mercury analyzer provides high selectivity of analysis, wide dynamic measurement range, ultra-low mercury detection limits for water and air and, in most cases, enables determination of mercury content in samples with a complex composition without preliminary sample preparation. It can be used in the field and in a laboratory as a stand-alone unit and as part of a computerized analytical system.

The RA-915+ mercury analyzer is a sophisticated high-precision device, therefore, it should be handled in compliance with operation conditions at all times to ensure its reliable operation.

After taking the device out of the package, make sure that you have everything necessary for its operation. The complete delivery set includes the following items:

1	Base unit	1 pc.
2	Display and control unit	1 pc.
3	Power supply unit (for operation from an a.c. mains)	1 pc.
4	Operation manual	1 pc.
5	Kit of spare parts and accessories (absorption and dust filters)	1 pc. each
6	Canvas shoulder bag (not pictured)	1 pc.
7	Display-unit-connection cable	1 pc.
8	Air intake hose with pre-filter	1 pc.
9	Analyzer-PC interface cable (RS-232 standard)	1 pc.
10	Software for RA-915+ (4 disks)	1 pc.



Options:

- RP-91C attachment for determination of mercury content in solid samples.
- RP-91 attachment for determination of mercury content in liquid samples.
- Cable for connection with an external d.c. power supply .
- Cable for analog signal input from a peripheral device.

Application

The RA-915+ analyzer (base unit) is intended for measuring mercury vapor concentration in 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 vapor concentration in the air both in a stationary mode and in continouous mode from vehicles (car, helicopter, boat).

The analyzer is used for tackling environmental problems, oil and ore deposit prospecting, technological processes monitoring, and for industrial sanitary and scientific research.

The RA-915+ analyzer is a part of a mercury analytical system, which enables determination of mercury content in gas, liquid, and solid samples. The analytical system consists of the RA-915+ analyzer itself, the RP-91 attachment for determination of mercury content in aqueous solutions using the "cold vapor" technique, and the RP-91C attachment for measuring mercury concentration in liquid and solid samples with a complex composition using the pyrolysis technique. Basic analytical characteristics of the system are given in the table below:

Subject	Detection limit	Sample parameters (flow rate, volume, weight)	Detection technique	Complete set
Ambient air	2 ng/m^3	20 l/min	Direct	RA-915+
Natural and industrial gases	2 - 500 ng/m^3	1 - 20 l/min		
Water	0.5 ng/l	20 ml	"Cold vapor" technique	RA-915+ RP-91
Urine	5 ng/l	1 ml		
Solid samples (soils, rocks)	0.5 μg/kg	0.2 g	Pyrolysis technique	RP-91C RA-915+
Biological samples (tissues, liver, etc.)	5 μg/kg	0.02 g		
Hair	20 μg/kg	0.01 g		
Oil and oil products	50 μg/kg	0.01 g		
Plants	2 μg/kg	0.05g		
Foodstuff	2 - 10 μg/kg	0.005 - 0.05 g		

Detection limit for mercury vapor concentration in air (ng/m^3), with the use of:

Multi-path cell	2
Single-path cell *	500

Maximum mercury vapor concentration under analysis (ng/m3), with the use of:

Multi-path cell	20 000
Single-path cell *	200 000

(*) in the “High concentration” mode

Accuracy, %	± 20

Main technical data and specifications

Built-it battery	6.3 V
External direct current source	10 – 14 V
A.C. power source, through external unit	220/110 V, 50/60 Hz
Power consumption	20 W
Dimensions (mm)	460 * 210 * 110
Weight (kg)	7.5

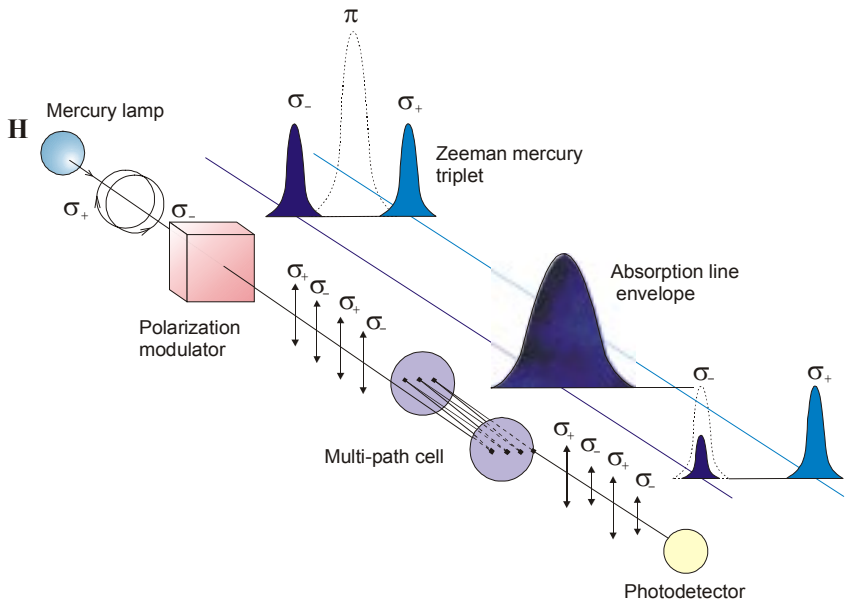
Operating conditions

Ambient air temperature	from +1 to 40 ^{0}C
Atmospheric pressure	84.0 – 106.7 kPa
Relative humidity	under 95 %, at 35 ^{0}C

Design and operation of the analyzer

Physical foundation and principle of operation

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



A radiation source (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, a photodetector detects only the radiation of the σ- components, one of those falling within the absorption line profile and another one lying outside. When mercury vapor is absent in the analytical cell, the radiation intensities of both σ_- components are equal. When absorbing atoms appear in the cell, the difference between the intensities of the σ- components increase as the mercury vapor concentration grows.

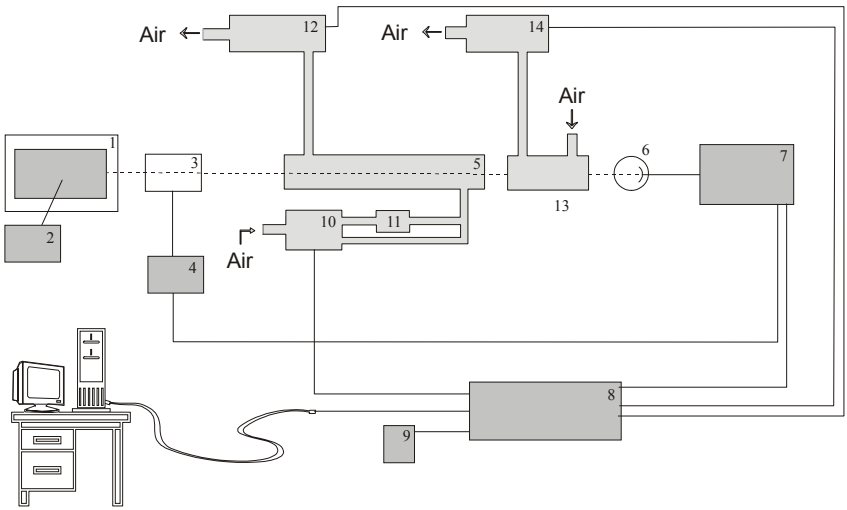
The σ_- components are separated by the polarization modulator. The spectral shift of the σ-components is significantly smaller than the widths of molecular absorption bands and scattering spectra, hence the background ab-

sorption 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.

Design of analyzer

Block diagram of the analyzer:

1) mercury EDL lamp
2) high-frequency generator
3) polarization modulator
4) modulator control unit
5) multi-path cell
6) photodetector
7) electronic signal-processing unit
8) built-in microprocessor
9) display and control unit
10) gas flow commutation unit
11) absorption filter
12) air pump of the multi-path cell
13) single-path cell or external cell (is part of the RP-91C attachment)
14) air pump of the single-path cell



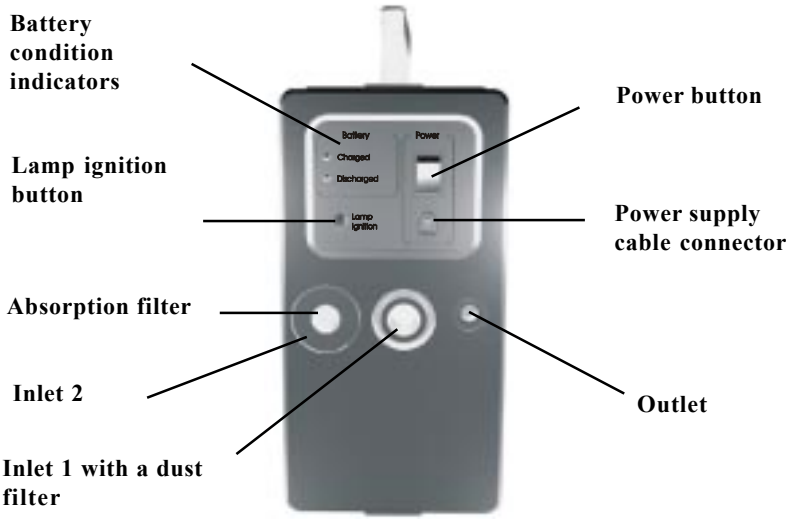
Mercury EDL lamp (1), which is placed in the gap between the poles of a magnet, is excited by high frequency generator (2). The light successively passes through polarization modulator (3), which is controlled by unit (4), multi-path cell (5), single-path cell (13) and is detected by photodetector (6). A signal from the photodetector then arrives at electronic signal-processing unit (7), where the signal is separated at the modulation frequency and the analytical signal is formed. After analog-to-digital conversion the signals come to a built-in micro-processor (8) for the final data processing.

The analyzer can be alternatively controlled as follows:

- From the display and control unit mounted in the base unit of the analyzer.
- From the display and control unit connected with the base unit via a signal cable.
- By means of an IBM-compatible computer connected with the base unit via an interface cable.

Appearance and functional controls

Front panel view



Inlet 1

The analyzer takes air into a multi-path cell with a built-in dust filter.

Inlet 1 (with the dust filter) is used for determination of the mercury vapor content in the air (or gas)

Inlet 2

This inlet is intended for the air intake into the multi-path cell through the built-in absorption filter.

Inlet 2 (with the absorption filter) is used only for baseline measurement.

Absorption filter

The absorption filter excludes mercury from the air/gas being analyzed.

Lamp ignition button

The button ignites the spectral lamp.

Battery condition indicators

CHARGED (green) - the battery charge indicator (does not glow during operation with the built-in battery). When the battery is being charged, the indicator flashes at a constant frequency. Duration of flashing indicates level of charge.
DISCHARGED (red) - the battery discharge indicator (does not glow during operation with an external power supply source). Duration of flashing indicates level of discharge.

Power button

The button switches on the analyzer.

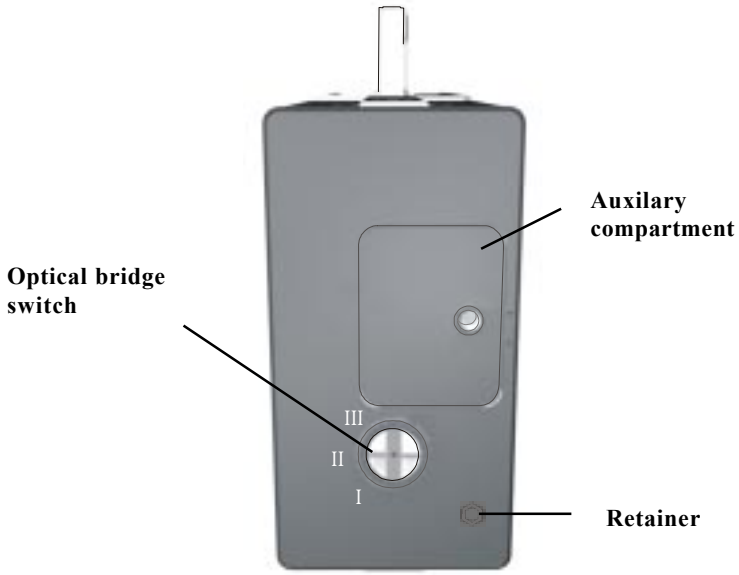
Power supply cable connector

It is intended for connection of the power supply cable for operation with an a.c. transformer.

Outlet

The air duct outlet of the multi-path cell.

Back panel view



Optical bridge switch

It is used for changing the position of the optical bridge. Light passes through different analytical cells when the switch is set in different positions:
Position I - through an external cell (pyrolysis).
Position II - through an accessory single-path cell (auxilary compartment).
Position III - through a built-in multi-path cell.

Position I is used only with the mounted optical unit of the RP-91C attachment.

Auxilary compartment

This is intended for the single-path analytical cell during operation with the RP-91 attachment, as well as for analyses of air, natural, or technological gases in the *HIGH CONCENTRATION* mode.

Retainer

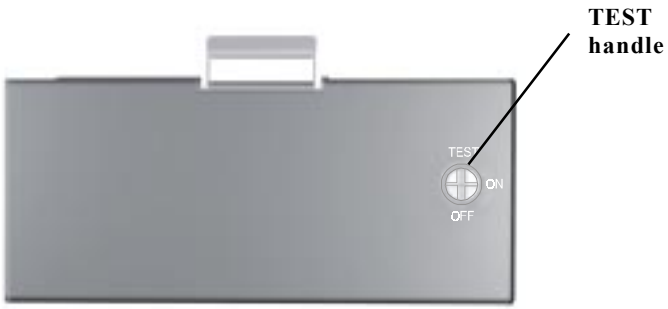
The retention screw is intended for mounting the optical unit of the RP-91C pyrolytic attachment.

Right panel view

Opening for a pyrolytic attachment

It is used for mounting an optical unit during operation with the RP-91C attachment.

Left panel view



TEST handle

The TEST handle is intended for placing a test cell in the optical path to check the serviceability of the device:
ON position - the test cell is placed into the light beam.
OFF position - the test cell is removed from the light beam.

Upper panel view

Connector

It is intended for connection of the display unit or a PC.

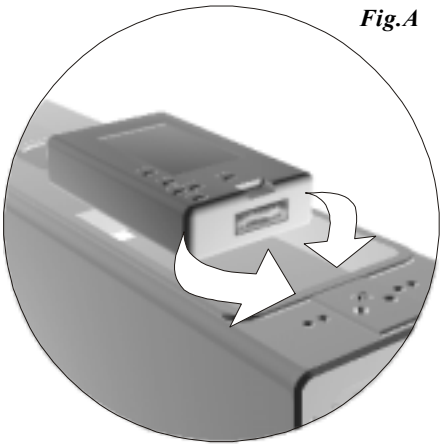
Pre-operational procedures

1 Prior to starting operation, make an external examination of the analyzer to be sure that there is no physical damage. Do not switch on the analyzer on your own if your analyzer has a physical damage. Call your regional dealer for replacement or repair of the analyzer.

2 Place the analyzer on a working surface so that the display unit is on top.

3 Select the operating mode (self-contained operation with the display unit or operation with a stand-alone PC). If the self-contained operation is chosen, install the display and control unit directly in the base unit (Fig. A) or connect it to the base unit with a cable, which is supplied with the analyzer (Fig .B).

Fig.A



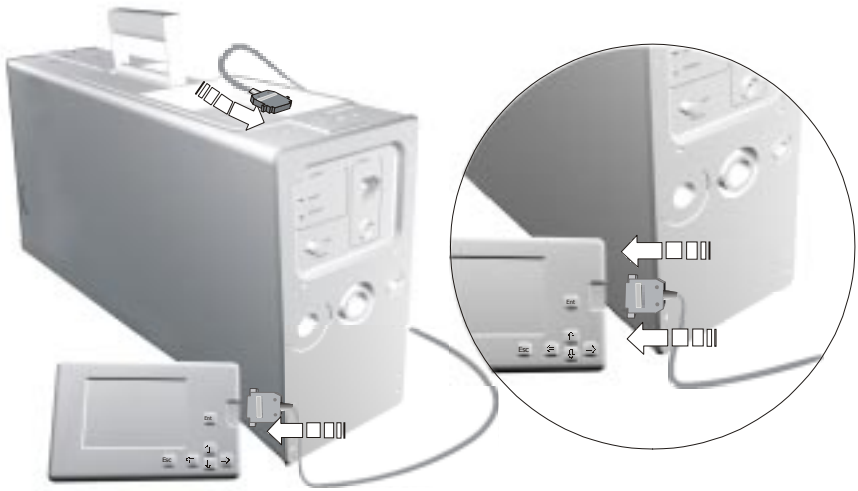


Fig. B

To operate with a stand-alone PC, it is necessary to connect the analyzer to the PC by the RS-232 cable, which is included into the basic package*. To connect the analyzer, do the following:

- Disconnect the analyzer from the a.c. power supply
- Switch off the PC.
- Insert the plug of the connecting cable into the socket of the interface connector on the upper panel of the analyzer.
- Insert the other end of the cable into a socket of the free COM-port of the PC and secure it.
- If your PC is not equipped with a 9-pin port, it is necessary to use a special adapter (not included).

*** When operating the analyzer as part of a computer system and when using additional devices (an autosampler, pressure transducers, etc.), which are connected to a PC, it is necessary to use a double cable, which is supplied upon request.**

Fig. C

4 Select power supply mode of the analyzer. If the built-in battery is chosen as a power supply, you can directly proceed to the preparation for measurements, because the analyzer is supplied with a fully charged battery. If you intend to operate using the transformer, do the following:

- Plug the low-voltage power adapter into the power supply cable connector on the front panel of the analyzer.
- Use a grounded connection with the appropriate voltage.

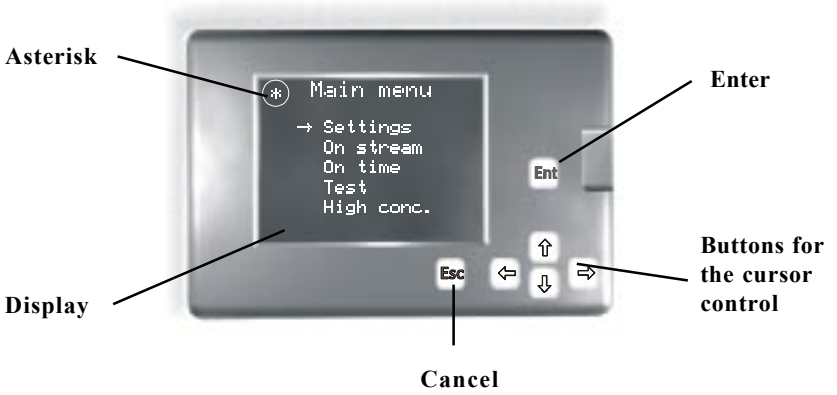
5 Prepare your analyzer for measurements. Set the handle of the test cell on the left panel into the OFF position and the optical bridge handle on the back panel to position III.

6 Switch the analyzer on with the power button located on the front panel.

Operation with the display unit

1 Upon switching on the analyzer, the manufacturer's trademark will appear on the screen of the display and control unit.

2 Press the Ent button on the display and control unit. The MAIN MENU will be displayed and the sign * (asterisk) will appear in the upper left corner.



3 Press and hold for several seconds the **LAMP IGNITION** button on the front panel of the device. When the spectral lamp turns on, the sign * (asterisk) will go out.

4 Let the analyzer warm up for at least 20 minutes. Then the device is ready for measurement.

*The presence of the sign * (asterisk) indicates that the spectral lamp is not glowing or that the lamp radiation intensity is low for measurements.*

Description of the MAIN MENU

SETTINGS

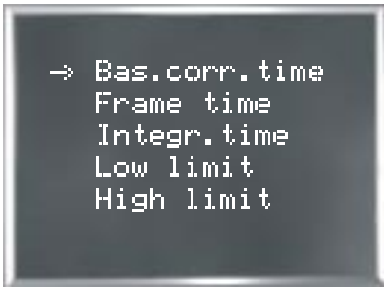
The *SETTINGS* command is intended for setting the operation parameters.

1 Using the cursor control buttons select the *SETTINGS* command on the display unit and press the **Ent** button. The **Settings** window will appear.

2 If you want to change the language, select the SELECT LANGUAGE command and press the **Ent** button. The **Select language** window will appear.

3 Select the language and press the **Ent** button. The language is installed. The **Setup** window will appear on the display.

4 Select the *PARAMETERS* command if you want to change the measurement parameters. The **Parameters** window will appear.



Bas. corr. time (sec). The baseline correction time is a period of time during which the level corresponding to the zero mercury vapor concentration in the analytical cell is measured over a range of 10 to 255 sec. The default value is 20 sec.

Frame time (sec). The frame time is a period of time during which an analytical signal is averaged over a range of 1 - 255 sec. The default value is 10 sec.

Integr. time (sec). The integration time is a period of time during which an analytical signal is integrated (summed up) in the *ON TIME* mode over a range of 1 to 255 sec. The default value is 150 sec.

Low limit (ng/m^3). The low limit is the value of the mercury vapor concentration in an analytical cell below which the deviation for three successive values of the mercury vapor concentration is not computed in the

PROTOCOL mode; in the *ON TIME* mode the device is ready for integration (the READY message appears). Range: 1 - 255 ng/m^3. The default value is 20 ng/m^3.

High limit (ng/m^3). The high limit is the value of the mercury vapor concentration in an analytical cell above which the ALARM warning appears in the *ON STREAM* mode; in the *ON TIME* mode it is the value below which the device is ready for integration (the READY message appears). Range: 1 - 10 000 ng/m^3. The default value is 100 ng/m^3.

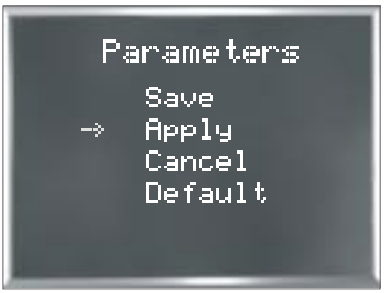
To change parameters by 1 unit, press the up or down arrows on the control panel.

To change parameters by 10 units, press the right or left arrows on the control panel.

5 Set the necessary parameters according to the task or to the measurement method desired.

6 Press the **Esc** button. The **Parameters saving** window will appear.

7 Select the necessary command.



Save – saves all the changes made.
Apply – temporarily saves the changes made.
Cancel – does not save changes in the parameters menu.
Default – set the parameters by default for the current session.

8 Press the **Ent** button.

TEST

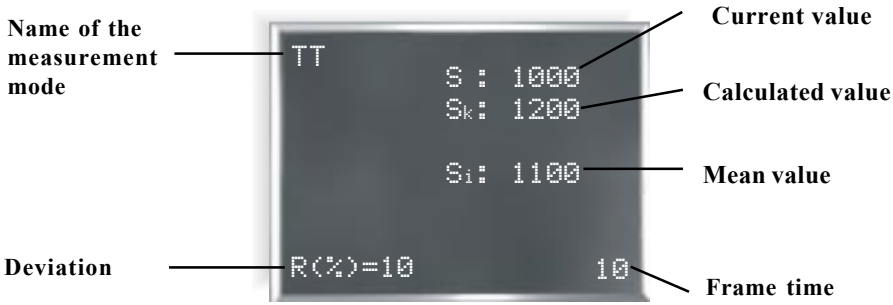
The *TEST* command is intended for checking the analyzer serviceability.

1 Set the TEST handle to the OFF positionI.
2 Select the TEST command on the display unit and press the **Ent** button.
3 The SET OPTICAL BRIDGE TO POSITION III message will be displayed.
4 Set the optical bridge to position III and press the **Ent** button.

The zero signal will be measured with the compressor on during the time you have preset (**bas. corr. time** in the **Parameters** window).

5 The ENTER THE TEST CELL message will be displayed.

6 Set the TEST handle of the test cell on the left panel of the unit into the ON position (after rotating it back and forth several times) and press the **Ent** button. The window for the device serviceability check will appear.



Current value (S). It is the mercury vapor concentration in the test cell at the current moment (it is displayed at a rate of 1 Hz).

Calculated value (S_k). It is the calculated mercury vapor concentration in the test cell, which depends on the temperature of the test cell. The temperature dependence of the calculated value is given in Appendix 2.

Mean value (S_i). It is the mean mercury vapor concentration determined during the accumulation time.

Frame time.It is the countdown of the accumulation time in seconds (**frame time**, the **Parameters** command).

Name of the measurement mode. TT - the serviceability check-up.

Deviation (R, %). It is the relative deviation of the measured value of the mercury vapor concentration in the test cell from the tabulated value. It is consecutively displayed and retained during the frame time.

*The **Temperature** message may appear during the analyzer serviceability check. This indicates that the temperature of the test cell falls out of the allowable temperature range.*

7 If relative deviation **R equals less than 25 %**, the device is ready for operation and you may proceed.

8 Press the **ESC** button. The REMOVE THE TEST CELL message will appear.

9 Set the TEST handle of the test cell to the OFF position and press the **Ent** button. The MAIN MENU will be displayed.

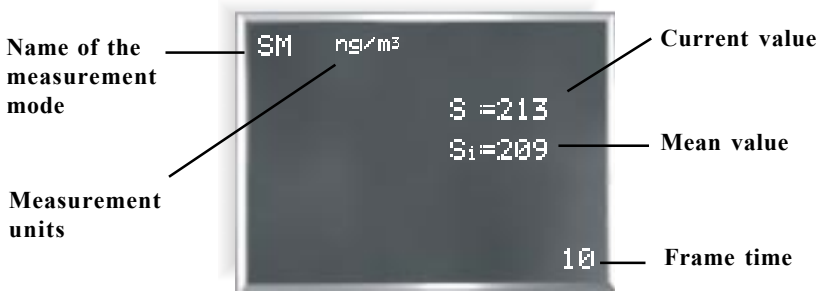
ON STREAM

The *ON STREAM* command is used for measuring the mercury vapor concentration in the air.

1 Set the TEST handle to the OFF position.
2 Set suitable parameters using the PARAMETERS command in accordance with the type of analysis.
3 Select the ON STREAM mode from the MAIN MENU and press the **Ent** button. The compressor will switch on and the zero-signal measurement will be performed during the preset time (**bas. corr. time**, the **Parameters** command).

To determine the mercury vapor concentration in the ambient air in the ON STREAM mode, default parameters are sufficient.

4 The SET OPTICAL BRIDGE TO POSITION III message will be displayed.
5 Set the optical bridge handle to position III and press the **Ent** button.
6 On completion of the zero-signal measurement, the window for operation in the *ON STREAM* mode will appear.



Current value (S). It is the mercury vapor concentration in the pumped air at the current moment. (It is displayed at a repetition rate of 1 Hz and is measured in ng/m^3).

Mean value (S_i). It is the mean mercury vapor concentration determined during the accumulation time. (It is displayed once per the accumulation time and is measured in ng/m^3).

Frame time. It is the countdown of the accumulation time in seconds (**frame time**, the **Parameters** command).

Name of the measurement mode. SM – the ON STREAM mode.

The compressor is switched on when the up arrow button is pressed at the display unit. The compressor is switched off when the down arrow button is pressed at the display unit. Switching off the compressor during pauses in operation extends battery life.

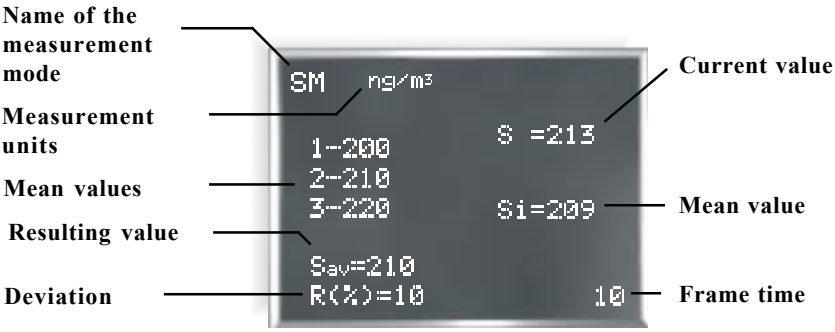
Measurement units. Mercury vapor concentration is measured in terms of ng/m^3.

1 ng/m^3 = 0.001 μg/m^3 = 0.000001 mg/m^3
1 mg/m^3 = 1000 μg/m^3 = 1 000 000 ng/m^3

*The **ALARM** warning may appear during operation in the **SM** mode. This means that the mercury vapor concentration in the air exceeds the preset **higt limit.***

The LOW RADIATION warning is highlighted if the value of the background absorption of the resonance radiation in the analytical cell exceeds the allowable level. In this case, the measurement is assumed to be invalid and it should be repeated.

7 When the **Ent** button is pressed during the ON STREAM operation, the device switches over to the *PROTOCOL* mode. This mode is intended for establishing three mean values of the mercury vapor concentration. We recommend the use of this mode for determination of the mercury vapor concentration in indoor air.



Current value (S). It is the mercury vapor concentration in the pumped air (it`s displayed at a repetition rate of 1 Hz and is measured in ng/m^3.

Mean value (S_i). It is the mean mercury vapor concentration determined during the accumulation time. It is measured in ng/m^3.

Frame time. It is the countdown of the accumulation time in seconds (**frame time**, the *PARAMETERS* command).

Name of the measurement mode. SM – On stream mode.

Measurement units. The mercury vapor concentration is measured in terms of ng/m^3.

Mean values. There are three consecutive mean values of the mercury vapor concentrations.

Resulting value (S_{av}). It is the resulting averaged value over three mercury vapor concentrations.

Deviation (R, %). It is the deviation of the three measured mercury vapor concentrations from the averaged value (in percent).

$$R = \frac{\left| S_{i\max} - S_{i\min} \right|}{S_{\text{av}}} \text{ x } 100\%$$

*The **R %** (deviation) value disappears if the resulting value **(Sav)** is smaller than the preset detection limit (**low limit**, the PARAMETERS command).*

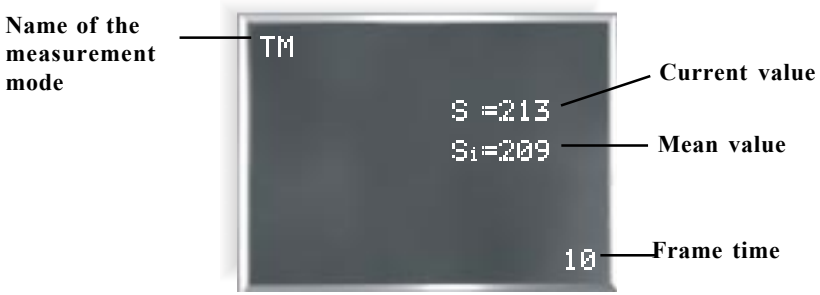
*When the back arrow button is pressed at the display unit, the analyzer switches over to the baseline check mode for the time that was preset in the **bas. corr. time** of the **Parameters** command.*

8 Press the **ESC** button to exit the *PROTOCOL* or *ON STREAM* mode. The MAIN MENU will be displayed.

ON TIME

The *ON TIME* command is intended for determination of the mercury vapor concentration in liquid and solid samples using the RP-91 and RP-91C attachments. This section describes basic instructions for operation with the *ON TIME* command. For more detailed instructions refer to the “Analyzer RA-915+ User`s manual. Operations with RP-91attachment” or “Analyzer RA-915+ User`s manual. Operations with RP-91C attachment”.

1 Prepare the RP-91 (RP-91C) attachment for operation according to the appropriate operation manual.
2 Set the optical bridge handle to position I for operation with an RP-91C attachment. If an RP-91 attachment is used, set the switch to position II or III for operation with the single-path or multi-pass cell, respectively.
3 If necessary, set the required measurement parameters in the **Settings window** according to the type of analysis.
4 Select the *ON TIME* command in the MAIN MENU and press the **Ent** button. This will initiate the baseline check during the preset time (**bas. corr. time** of the **Parameters** command).
5 **Integration waiting window** will be displayed.



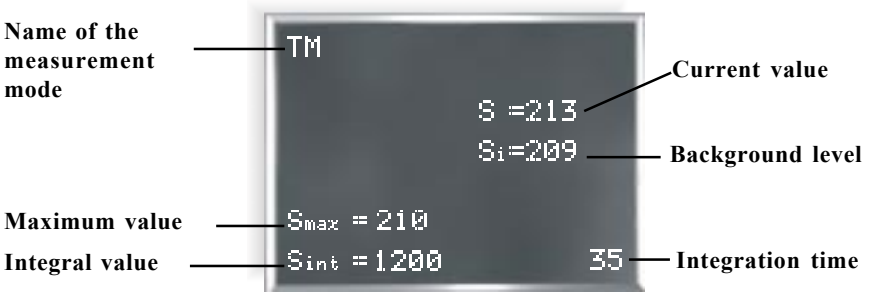
Current value (S). It is the mercury vapor concentration in the analytical cell at the current moment. (It is displayed at a repetition rate of 1 Hz.

Mean value (S_i). It is the mean mercury vapor concentration determined during the accumulation time.

Frame time. It is the countdown of the accumulation time in seconds (**frame time** of the **Parameters** command).

Name of the measurement mode. TM – on time mode.

6 Measuring can be started after the READY message appears.
7 Press the forward arrow button at the display unit and introduce a sample into the reaction vessel. The INTEGRATION PHASE window will appear on the display.



Current value (S). It is the mercury vapor concentration in the analytical cell at the current moment (it is displayed at a repetition rate of 1 Hz.

Background level (S_i). It is equals to the last mean value of the mercury vapor concentration obtained before the forward arrow button was pressed.

Integration time. It is the direct count of the integration time in seconds (**integration time**, the **Parameters** command).

Name of the measurement mode. TM – on-time mode.

Maximum value (S_{max}). It is the maximum value of the mercury vapor concentration obtained during the integration time with respect to the background level.

Integral value (S_{int}). It is the integrated signal, which is proportional to the mercury amount in a sample (displayed after the measurement is finished).

The LOW RADIATION warning is highlighted if the value of the background absorption of the resonance radiation in the analytical cell exceeds the allowable level. In this case, the measurement is assumed to be invalid and it should be repeated after, for example, diluting the sample or reducing its weight.

8 The integration is completed automatically when the preset integration time elapses (**integration time**, the **Parameters** command).

The integral values of the signal, S, exceeding 9999 are displayed as XXXE2, which corresponds to a decimal number equal to XXX10^2 (for example, 231E2 means 23100).*

To enhance the measurement accuracy, we recommend stopping the integration process by pressing the back arrow buton when the READY message recurs.

9. Press the **Ent** button. The analyzer will switch over to the INTEGRATION STANDBY PHASE mode.
10. Press the **ESC** button to stop measuring. The MAIN MENU will be displayed.

HIGH CONCENTRATIONS

High concentrations measuremant mode (HC). This command is intended for determination of the mercury content in atmospheric air if its concentration exceeds the 500 ng/m^3 level. In this case, the mercury vapor concentration is measured in the single-path cell compartment with the air pump idling. In this mode, the air is exchanged by convection only. When this mode is selected, a window similar to that for the ON STREAM mode appears with the same designations, except for the name of the operation mode. In this case, the zero-control is carried out by placing a closed small cell into the compartment at the back panel of the analyzer. The small cell should be filled with air, in which the mercury vapor concentration is lower than 500 ng/m^3. If such a cell is unavailable, the zero-signal can be measured outdoors, in the open air.

Operation with a PC

This section contains basic instructions for operating the analyzer with a PC. For more detailed instructions refer to the “Analyzer RA-915+ User`s manual. Operation with a PC”.

1 Make sure that the device is on and is connected to the PC. Start running the RA-915+ program.
2 Select the AIR mode in the Main menu. The Air analysis window will appear.
3 Press the LAMP IGNITION button on the front panel of the analyzer. Now the analyzer is ready for operation.

The LOW INTENSITY warning, which appears in the upper right corner of the window, means that the lamp radiation intensity is insufficient for measuring. After pressing the LAMP IGNITION button, this warning will disappear.

Serviceability check-up

1 Set the TEST handle of the test cell to the OFF position.
2 Select the Test mode button in the Air analysis window.
3 Two black lines will appear on the graph and the current readings will be displayed.
4 Set the TEST handle of the test cell to the ON position.
5 The signal, which is obtained when the test cell is installed, will appear on the graph.

If the signal, which was obtained when the test cell was installed, falls within the area between the two black lines, the device is ready for measurements.

Measuring procedure

Select the Graph command. Click the Start button. Follow the instructions on the display.

Maintenance

Maintenance of the analyzer includes:

- Daily visual inspection
- Battery charging
- Changing of the dust filters (inlet port, pre-filter)
- Changing the zero mercury absorption filter
- Preventive maintenance

During daily visual inspection make sure that there is no physical damage of the analyzer housing and of its parts. Ensure that all the cables are undamaged and securely fastened. Check the analyzer serviceability each time before starting measurements using the TEST mode.

Charge the battery. Do not store the unit with a discharged battery for more than three days to avoid permanent damage.

Charging the battery

The battery is charged when the analyzer is connected with the transformer. If it is only necessary to charge the battery without making measurements, we recommend not switching on the power button of the analyzer.
It takes 5 hours to charge a dead battery. Longer charging time does not cause damage to the battery. The fully charged battery provides continuous operation of the analyzer for approximately 3.5 hours.

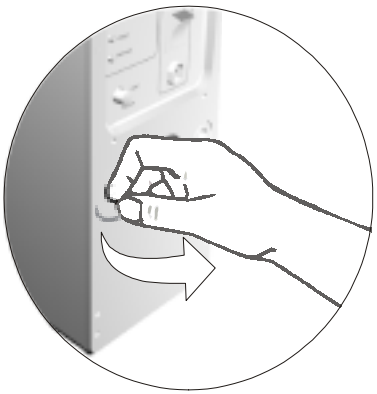
Changing of the dust filter

Change the dust and absorption filters on a regular basis, especially when operating under dusty conditions.

When changing the dust filter, the device should be switched off.
The dust filter is located in the Inlet 1 at the front panel of the analyzer. To remove the filter from the analyzer, grip it with tweezers and pull it out. Insert a new filter into Inlet 1, excercising caution not to push through the screen on the valve.

Changing of the absorption filter

The absorption filter is located in the Inlet 2 at the front panel of the analyzer. To remove the filter from the analyzer, pull it straight out. Insert a new filter into Inlet 2 and push it flush with the front panel.



Changing the Pre-filter

See separate instruction manual provided with the unit.

Preventive maintenance

During preventive maintenance check the housing covers and, if necessary, change the dust and absorption filters.
Handle the multi-path cell carefully! Prevent ingress of foreign substances into the cell, metal mercury in particular. Avoid long operation with the multi-path cell in rooms with high mercury vapor concentration (higher than 10 000 ng/m3). In this case, it is preferable to use the HIGH CONCENTRATIONS measuring mode. If the multi-path cell has been contaminated, do the following:

- Remove the dust filter using tweezers.
- Blow hot air through the cell for several hours using, for example, a hair-drier.
- Install a new dust filter.

It is recommended to carry out annual pre-verification preventive maintenance of the analyzer at a regional service center, followed by a calibration of the device.

On completion of operation with the analyzer, take it indoors with the ambient air temperature of 5 - 40 ^{0}C and relative humidity not higher than 98 % at 30 ^{0}C. The ambient air should not contain corrosive impurities.

If you will not operate the analyzer for a long time, store it in the following manner:

- Charge the battery fully.
- Put the RA-915+ analyzer into a polyethylene cover with 0.8 kg of the silica-gel dryer and hermetically seal the case. Store the analyzer indoors at the ambient temperature of - 50 ^{0}C + 50 ^{0}C and relative humidity below 98 % at +35 ^{0}C.

Appendix 1

Troubleshooting

The RA-915+ analyzer should be repaired only at an authorized service center or by the manufacturer.

Prior to returning the unit for repair, check the troubleshooting table given below.

Fault symptom	Possible cause	Remedial measure
Segments of the indicator table on the display and control unit are not highlighted when the analyzer is switched on	- Power cable is out of order - Display unit cable is out of order - Battery is discharged	- Repair the power cable - Repair the display unit cable - Charge the battery
The (*) symbol at the display and control panel is not dimmed out when the "Lamp ignition" button is pressed:	- Battery is discharged	- Charge the battery
- if the optical switch is in position I	- Operation is possible only with attachments	- Set the optical switch into positions II or III
- if the optical switch is in position II	- The single-pass cell is contaminated, compartment windows are contaminated or foreign objects are found in the compartment	- Remove the single-path cell, check if the compartment windows are clean, make sure that there are no foreign objects inside the compartment
- if the optical switch is in position III	- Multi-path cell is contaminated	- Clean the multi-path cell (see appropriate section)
The battery discharge indicator (red) glows for some time and then goes out when the analyzer is switched on.	The battery is fully discharged	Charge the battery
In the TEST mode, relative deviation R of the measured test number differs from the tabulated value by more than 25 %.	- Spectral lamp is not switched on - The test cell switch is in idle position - The test cell is out of order - The absorption filter has failed	- Press the "Lamp ignition" button - Set the switch of the test cell to the working position - Shake the test cell 2 - 3 times by the TEST (ON/OFF) switch - Replace the filter

Appendix 2

Values of the test number Sk as a function of the temperature of the test cell (step 1^0C)

T , °C	Sk	T , °C	Sk
1	320	21	1650
2	347	22	1791
3	377	23	1943
4	409	24	2109
5	445	25	2291
6	482	26	2485
7	524	27	2698
8	568	28	2929
9	616	29	3180
10	669	30	3451
11	727	31	3750
12	788	32	4060
13	856	33	4410
14	929	34	4790
15	1008	35	5200
16	1095	36	5640
17	1188	37	6130
18	1290	38	6650
19	1400	39	7220
20	1519	40	7835

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