RA 915 AM

Automatic Mercury Monitor

LUMEX®

RA-915 AM
Automatic Mercury Monitor for Ambient Air

Operation Manual

RA-915AM Rev A-6, April 2015

Address: Head Office Russian Federation
70/2, pr. Obuhovskoy Oborony, St. Petersburg 192029
Tel: (+7) 812 718 5390
Fax: (+7) 812 718 5399
e-mail: sales@lumex.ru
Web site: www.lumex.ru

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Manual History

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Notice

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Mark Declaration

Declaration of Conformity

Automatic Mercury Monitor

Scope of Declaration

This declaration applies to Automatic Mercury Monitors as manufactured by Lumex Ltd and which may be sold in the following configurations:

Part Number	Description
5-070-001	Automatic Mercury Monitor for Ambient Air, 0–2000 ng/m^3

Symbols and Conventions Used on Lumex Equipment and in this Manual

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

Warning Used when there is a danger of minor injury or serious damage to the system if you do not follow the precautions.

Caution Used when there is a danger of minor damage to the system if you do not follow the precautions.

Safety Requirements

The Monitor should only be used by qualified staff and for the purpose it is intended for. Read this manual carefully before installing, commissioning or operating the Monitor. Pay attention to the safety warnings at all times.

General Safety Precautions

This Monitor contains electrical components operating under dangerously high voltages, which can be exposed when covers or parts are removed. Contact may result in electric shock and severe or fatal injury.

- All maintenance and repair work, which requires the Monitor cabinet to be opened may only be performed by qualified personnel, using only parts specified by the manufacturer.
  Make sure the Monitor is properly earthed before switching it on.
  Check the power cable for damage, and do not switch the Monitor on if the cable is kinked, damaged or cut.
  Switch the Monitor off before starting maintenance or repair work.
  Prevent water from entering the Monitor cabinet
  Special precautions are required in environments with corrosive gases, vapours or explosion hazards.

Safe Disposal

The lamp and the calibration cell contain small amounts of elemental mercury (approx. 10 mg). After the lamp lifetime has expired, manufacturer will replace the lamp, and will take care of the safe disposal of its contents.

Equipment Rating

- 220 – 240 V ~
- 50/60 Hz
- 120 VA max
- All wiring must be in accordance with local norms and be carried out by experienced personnel

Environmental Conditions

- Operating Temperature 22 ± 2 °C
- Relative Humidity 95%

Monitor is suitable for use in a sheltered environment only.

Cross Sensitivities

The following concentrations of air pollutants are tolerable without impairing the specified measuring performance:

	Mercury concentration range	
	0.5 -10 ng/m^3	10 – 2 000 ng/m^3
Benzene	0.1 mg/m^3	1 mg/m^3
SO_2	1 mg/m^3	10 mg/m^3
O_3	1 mg/m^3	
H_2S	10 mg/m^3	
NO_x		

Claims for Damaged Shipments and Shipping Discrepancies

Damaged Shipment

1) Inspect all instruments thoroughly on receipt. Check material in the container(s) against the enclosed packing list. If the contents are damaged and/or the instrument fails to operate properly, notify the carrier and Lumex immediately
2) The following documents are necessary to support claims:
   a) Original freight bill and bill of lading
   b) Original invoice or photocopy of invoice
   c) Copy of packing list
   d) Photographs of damaged equipment and container

You may want to keep a copy of these documents for your records also.

Refer to the instrument name, model number, serial number, and purchase order number on all claims. Upon receipt of a claim, we will advise you of the disposition of your equipment for repair or replacement.

Shipping Discrepancies

Check all containers against the packing list immediately on receipt. If a shortage or other discrepancy is found, notify the carrier and Lumex immediately. We will not be responsible for shortages against the packing list unless they are reported promptly.

Service and Spare Parts

For service and spare parts contact

in Europe: Lumex Analytics GmbH

Address: Naher Str. 8,
D-24558
Wakendorf II

Phone: +49 (4535) 29-77-56 (58)
Fax: +49 (4535) 29-77-83

E-mail: info@lumexanalytics.de
Web: www.lumexanalytics.de

Worldwide: Lumex Ltd.

Address: 70/2, pr. Obuhovskoy Oborony
St. Petersburg 192029
Russian Federation

Phone: +7 812 718 5390
Fax: +7 812 718 5399

E-mail: sales@lumex.ru
Web: www.lumex.ru

Our Service Center will inform you about the service station closest to you.

1 Description

1.1 Area of Application

The Monitor is designed for the continuous measurement of the mass concentration of mercury in ambient air. They are used in control of technological processes, occupational health services, environmental and scientific investigations. To achieve the specified performance, the Monitor should be operated in an air-conditioned room with a temperature variation of max. ± 2°C.

1.2 Operating Principle

A block diagram of the pneumatic and electric layout is shown in Figure 1.1.:

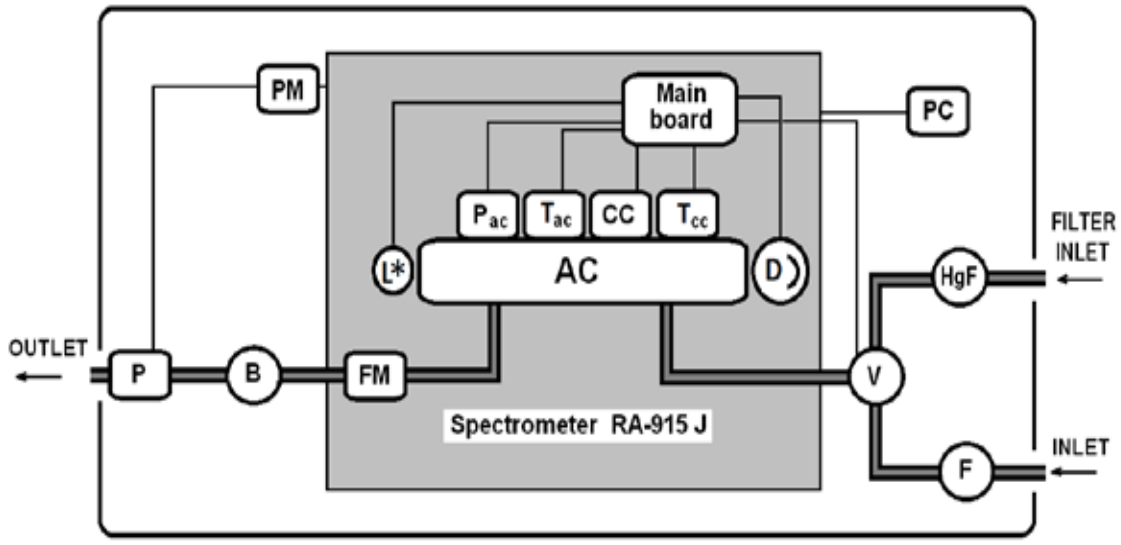


Figure 1.1. Block Diagram of Automatic Mercury Monitor for Ambient Air

A membrane pump **P** draws ambient air either through a dust filter **F** or a mercury filter **HgF** into a multipath optical cell **AC**. In cell **AC**, which has an optical path length of about 10 m, a spectrometer determines the mercury concentration by Zeeman atomic absorption spectrometry using high frequency modulated polarized light (ZAAS-HFM).

The measurement principle is illustrated in Figure 1.2.:

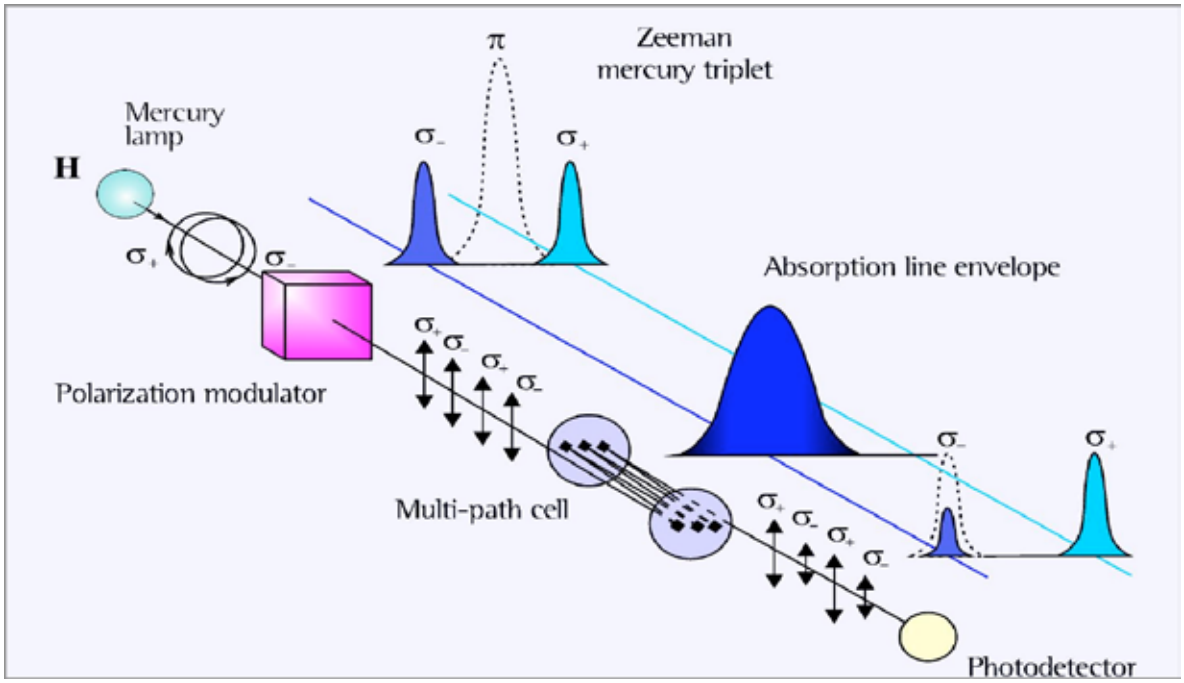


Figure 1.2. Principle of ZAAS-HFM

A Mercury Electronic Discharge Lamp **L** is placed in a strong magnetic field **H**, by which the mercury resonance line at 254 nm is split into the three polarized Zeeman components σ_-, π and σ_+. Only the σ-components of the electro-magnetic radiation will be registered by the photodetector **D**. σ_+ and σ_- are separated by a polarization modulator.
As long as mercury vapour is absent in the multipath cell, the intensities of both σ-components are equal. When mercury is admitted to the cell, the difference in intensities between the two σ-components increases as a function of the mercury concentration.
As the spectral shift between the σ-components is significantly smaller than the widths of molecular absorption bands and scattering spectra, any background absorption by interfering compounds can be neglected.

Thus, differential Zeeman AAS with high frequency modulated light provides ultra low detection limits below 1 ng Hg/m^3 plus absence of cross-sensitivities against other contaminants in air.

After leaving the cell, the gas is passing a buffer tank **B** and is then vented to the atmosphere. Gas flow is controlled by a pressure transducer $\mathbf{P_{ac}}$ and a mass flow meter **FM**. Temperatures of the cell and the gas flow are constantly monitored by temperature sensors $\mathbf{T_{ac}}$.
The whole unit is controlled by an industrial panel **PC**, and powered by a power module **PM**, backed-up by an uninterruptible power supply UPS (optional).

A general view of the Monitor is given in Figure 1.3.

Figure 1.3. RA-915 AM Automatic Mercury Monitor for Ambient Air

1.3 AUTOCAL Function

Using carefully designed calibration cells (CC), containing sufficient elemental mercury to form a saturated mercury gas, and measuring precisely the temperature of the cells, it is possible to calibrate the analytical module without the use of mercury standard solutions, permeation tubes or gases. In the calibration cells there is equilibrium between liquid and gaseous mercury. The saturation concentration of mercury in the gas phase is only a function of temperature, and can be expressed as:

$$C_{sat} = \frac{mP^{0}_{Hg}}{RT}$$

where C_{sat} is the actual mercury concentration, P^{o}_{Hg} is the saturated mercury vapor pressure at temperature T (°K), m is the atomic weight of mercury, and R is the universal gas constant. The saturation vapor pressure of mercury as a function of temperature is well documented.

Mercury concentration is then calculated as:

$$C = C_{sat}\frac{l_{cal}}{L_{anal}}$$

where C is the theoretical mercury concentration, C_{sat} is the concentration of saturated mercury vapors in the calibration cell. l_{cal} is the length of the calibration cell. L_{anal} is the length of the multipath cell.

The calibration cell is moved into the light path of the spectrometer when AUTOCAL is performed. The measured mercury concentration is then compared to the theoretical mercury concentration, and a calibration factor calculated.
A zero-mercury gas to check the Monitor's zero point is obtained by passing an ambient air sample through a mercury filter **HgF** to remove traces of mercury.

There is an option to calibrate the Monitor also by injecting a calibration gas mixture directly into the gas inlet port.

1.4 Data Communication

Analytical data, normalized to 273/293 K and 101.3 kPa, and status signals are transmitted to the central immission control computer in the Gesytec protocol via a RS232 interface or Modbus protocol via LAN.

Analytical data and status signals are saved on a built-in hard disc in the format given in Table 1.1.
It is possible to copy the data via the USB ports on the front panel of the Monitor. It is necessary to delete ***.dat** files from the hard disk once per year.

Table 1.1. Data File Format Results.dat

№*	Information	Format	Comment
1	Date	dd.mm.yyyy	
2	Time	hh:mm:ss	
3	Date	OLE-automation	
4	Temperature of the control cell, T_{cc}	°C	
5	Air flow rate	l/min	
6	PMT voltage	arb.un.	
7	Drift of zero readings within measurement time	ng/m^3	
8	Calibration coefficient of the monitor	arb.un.	Value set at the last calibration
9	SD of zero readings		
10	Mercury concentration	ng/m^3	Mean value calculated within measurement time considering zero drift
11	Code of the mode	0	Measurement
		1	Service
		2	Zero level after external request
		3	Control cell level after internal request
12	QC (quality control) code of the results	0	The results are valid
		1	The concentration is below the admissible lower threshold
		2	The concentration is above the admissible upper threshold
		3	Zero drift within measurement time is above the admissible value
		4	SD is above the admissible value
		5	PMT voltageis is out of the admissible range

1.5 Technical Specifications

Analytical	
Measured Component	elemental Mercury
Range Flow	0 – 2 000 ng/m^3
Lower Detection Limit	0.5 ng/m^3
Reporting Interval	5 min to central immission control computer
Zero Drift Correction Span Drift Correction	automatically once every 5 min automatically once every 6 hrs
Gas Flow	7 – 10 l/min
Data Communication	
Data Presentation	Touch panel PC with 6.4" screen
Concentration data output	Normalized mercury concentration (293 K, 101.3 kPa)
Data Storage	4 GB HDD will store data of 360 days (24 hrs measurement time)
Communication Ports	4 -20 mA current loop (0 – 2000 ng/m^3); 2 x USB; RS 232; LAN
Communication Protocol	Standard: GESYTEC protocol, Modbus
Status Outputs via potential-free contact	WORK; SERVICE
Operating Conditions	
Ambient air temperature	-20°C to +50°C
Atmospheric pressure	84 to 106.7 kPa
Ambient relative humidity	< 99% at 35°C
Power	220 – 240 VAC, 50 Hz; max 120 VA
Dimensions	600 x 480 x 220 mm
Weight	19 kg

2 Installation and Operation

2.1 Transport and Storage

The Monitor shall only be transported in the factory packaging and in an upright position, determined by the sign “Top”.

The Monitor shall be stored indoors at ambient temperatures between 5 and 40 °C, and relative humidity not exceeding 99% at 30 °C. The air at the storage facility shall not contain corrosive vapours.

Table 2-1: Scope of Supply

№	Description	Quantity, pcs	Catalogue code
1	RA-915 AM	1	5-070-001
2	Power Cable, 230 VAC	1	5-014-033
3	Observer Software, pre-installed	1	5-012-001
Spares Kit:			
4	Mercury Filter	1	5-054-007
5	Dust Filter Holder (in assembly)	1	5-074-011
6	Dust filter	3	5-074-010
7	Installation’s wrench (for Dust filter)	1	5-074-002
8	Mains Fuse, 5A	2	6-104-004
9	L-key for monitor, 3мм	1	6-104-017
10	Ferrule, D = 6 мм	3	5-074-012
11	Lamp assembly for RA-915AM	optional	5-074-001
Documentation:			
12	RA-915 AM Operation Manual	1	5-073-001
13	Calibration Certificate	1	5-013-017

2.2 Mechanical Installation

Before installation, the Monitor should be checked to ensure that it has arrived undamaged.

The Monitor can be installed into a 19” rack by fastening the front panel to the rack with four screws. For easier serviceability, it is recommended to mount the Monitor on a fully extendable shelf with telescopic slides (available as an accessory). For installation, follow the assembly instructions provided with the rack-mount kit. Figure 2.1. shows a view of the Monitor’s front panel.

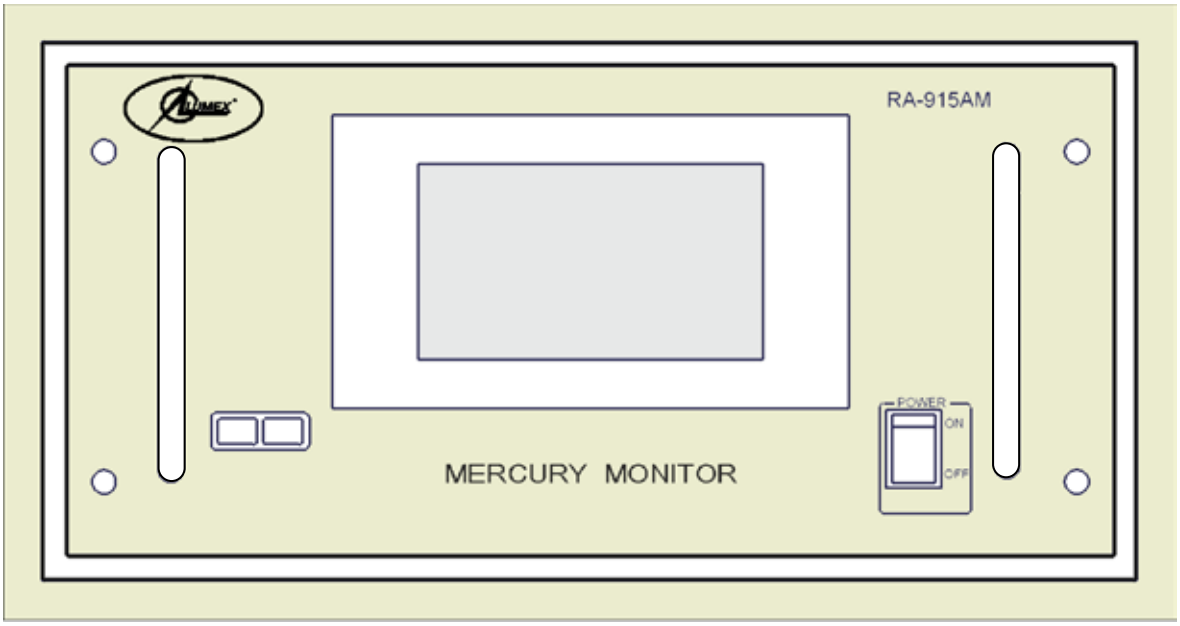


Figure 2.1. RA-915 AM Front Panel

⚠ CAUTION

Rack-mounting requires a properly ventilated rack enclosure. The temperature inside enclosures that are not properly ventilated may rise as much as 15 °C above the ambient air temperature. This may force the Monitor to operate outside of specifications. For ventilation calculations, use a heat dissipation rating of 100 Watts.

2.3 Sample Gas Connection

⚠CAUTION

Sample gas connections to the Monitor should be maintained at ambient pressure, with any excess flow vented to the atmosphere.

The Monitor requires at least 7 l/min of non-condensing sample at all times.

The rear panel of the Monitor is shown in Figure 2.2.

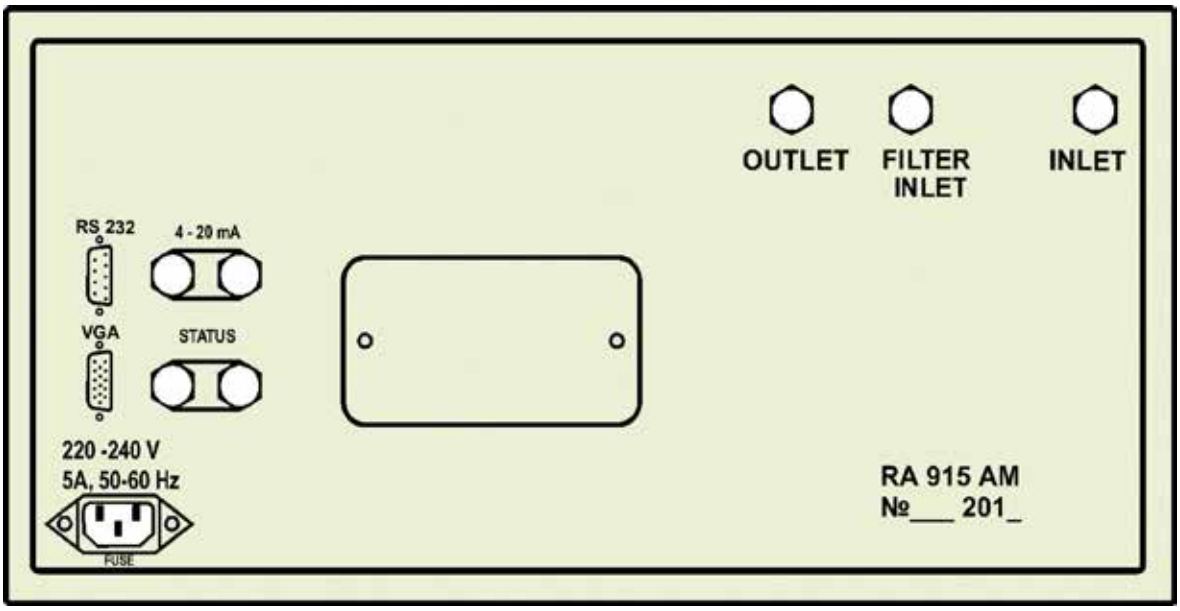


Figure 2.2. RA-915 AM Rear Panel

The sample inlet and outlet ports and the zero gas port of the Monitor are equipped with 6 mm (or 1/4") Gyrolok fittings. Connect the inlet port and zero gas port to the same sample tapping point, and the outlet port to the vent by appropriate PTFE or PFA tubing (available as an accessory). Allow enough length to slide the Monitor out of the rack.

2.4 AC Power Connection

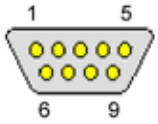
⚠WARNING

Power is supplied to the Monitor through a three-pin power plug. The ground must not be defeated and an adequate ground must be connected to the Monitor, both for proper performance and for the safety of operating personnel. The warranty on the Monitor applies only if the Monitor is properly grounded. If it is not properly grounded and electric power is applied in violation of national laws, Lumex assumes no responsibility for any injury or damage to personnel or property.

Connect the power cable supplied with the Monitor to the power receptacle on the rear panel.

2.5 Signal Output Connections

2.5.1 RS-232 connector provides standard serial communication signals as DTE. Pin out and signal description are represented in the tables below.



9 pin D-SUB male connector

Pin	Name	Description
1	CD	Carrier Detect
2	RXD	Receive Data
3	TXD	Transmit Data
4	DTR	Data Terminal Ready
5	GND	System Ground
6	DSR	Data Set Ready
7	RTS	Request To Send
8	CTS	Clear To Send
9	RI	Ring Indicator

Mode of Operation	half duplex
Communication Rate	1200 baud
Data format:	
Data length	8 bits
Start	1 bit
Stop	1 bit
Parity	none

2.5.2 The USB ports on the front panel provide standard communication options as USB host under Windows XP. They can be used to connect a keyboard, mouse or flash drives.

2.5.3 The analytical signal (mercury concentration) can be transmitted to the control room via the current loop (4 – 20 mA). Current loop connectors are placed on the rear panel of the Monitor. The red connector is «+».

2.5.4 Two status signals can be transmitted from the Monitor to a control room via its potential-free contact:

Status contact:	Open	Short-circuited
Status outputs:	«SERVICE»	«WORK»

Four different status signals can be transmitted from the Monitor to the centralimmission control computer (see Table 1.1 raw 11 - Code of the mode).

2.6 Start-Up Procedure

Turn on the "Power" switch on the front panel. A red indicator lamp should light up. The air sample pump will start to work and the Windows XP operating system will boot. The Lumex Observer software will install itself, presenting the cover screen with the version identification number. After a few minutes, a screen like the following will be displayed on the touch panel:

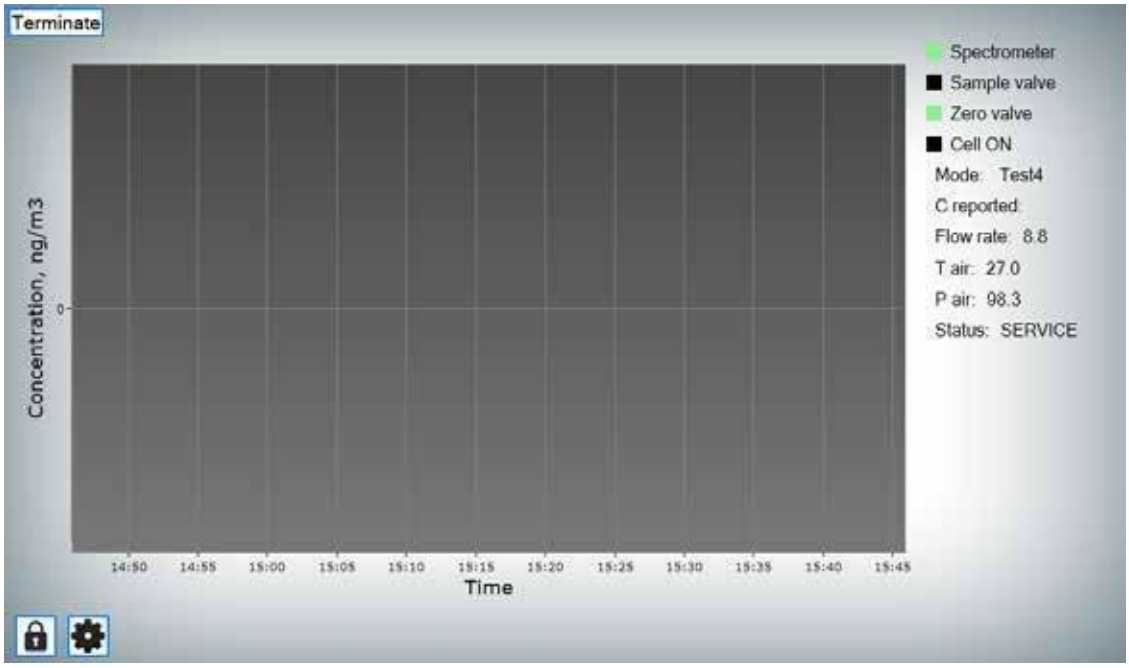


Figure 2.3. View of the display on Start-up

During Start-up procedure (approximately 15 mitutes) the status signal «SERVICE» is transmitted and there is no graph of the averaged mercury concentration on the display.

After Start-up, zero control and calibration by the internal mercury standard are performed automatically, followed by another zero control. From this procedure, a calibration coefficient is calculated. If this coefficient falls outside the limits specified during the factory tests, the Monitor performs a self-check, after which the zero/calibration procedure is repeated. In case the Monitor

doesn’t switch to status WORK, please call a LUMEX office for help.

As soon as the first averaged value of measured concentration comes into sight on the screen, the status and an analytical signal are transferred on request of the central immission control computer.

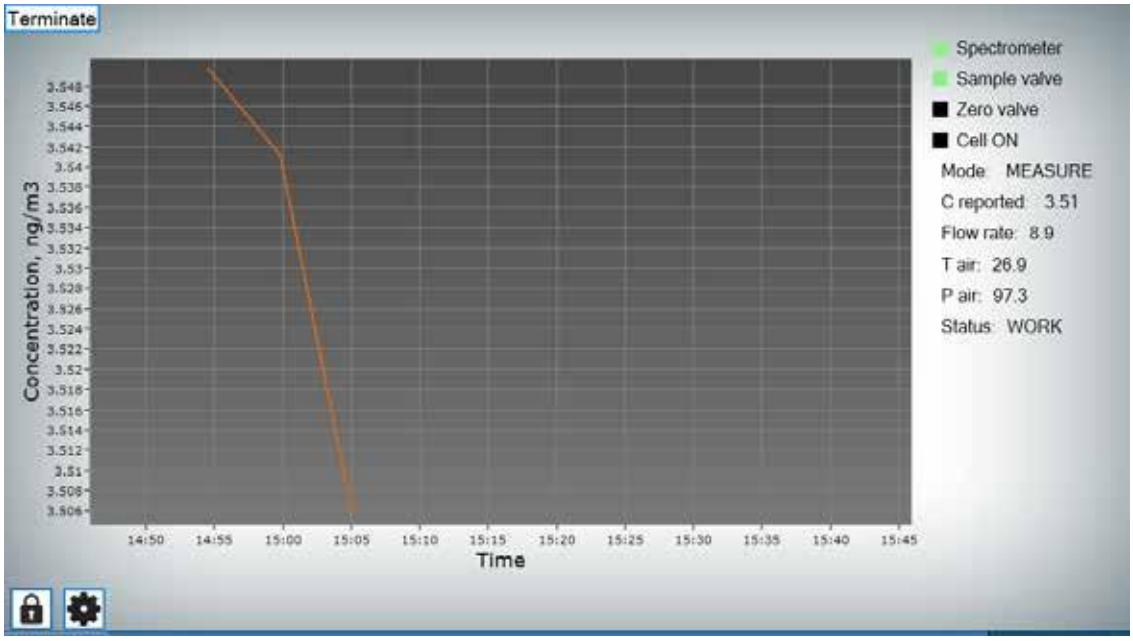


Figure 2.4. View of the display on measurements

2.7 Routine Operation

On measurements the window shown in the Fig. 2.4 is displayed on the computer screen. Length of the X-axis is defined by a parameter **Length of X axis**, **minutes** parameter on the User tab and renewed automatically. Scale on the Y-axis is automatically managed by the software depending on maximum of the concentration values. It is possible to change the current scale of the graph using mouse or stylus:

- To zoom a fragment of the graph move mouse or stylus from the upper left corner of the graph fragment of interest (pressing and holding the left mouse button) to the lower right corner;
- To return to the standard scale of the graph move mouse or stylus from the lower right corner (pressing and holding the left mouse button) to the left upper corner of the graph.

The maximum value on the Y-axis can be fixed. To do this, deselect the **Automatic Y axis scale** checkbox on the User tab and enter the required value in the **Y axis max** field.

To change the monitor parameters click the button in the left lower corner of the **Lumex Observer** software (Fig. 2.4.). The window shown in the Fig. 2.5. will be displayed in the screen

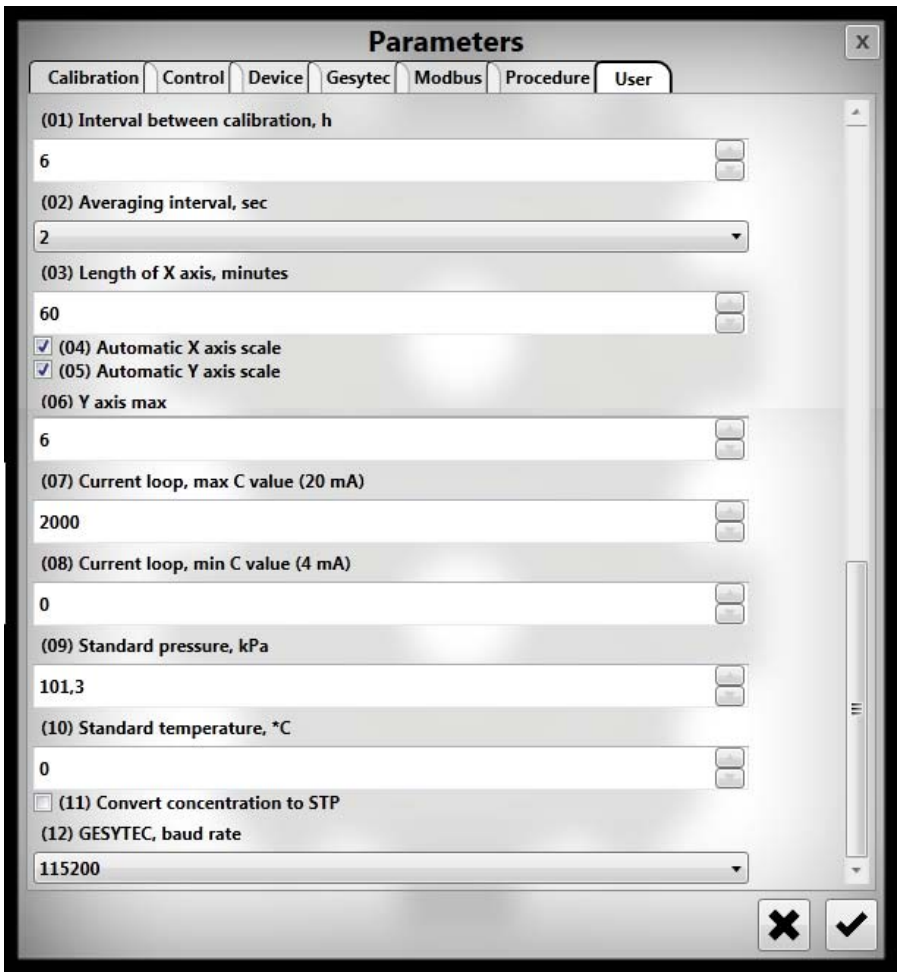


Figure 2.5. View of the Parameters window

Set the following parameters on the User tab of the Parameters window (values by default are shown in the Fig. 2.5.):

- **(01) Interval between calibration, h** – periodicity of the calibration procedures;
- **(02) Averaging interval, sec** – time interval, within which instant concentration values are averaged;
- **(03) Length of X axis, minutes** – time interval, within which measured concentration values are displayed on the graph. When the interval is finished renewing of the X-axis is automatically performed;
- **(04) Automatic X axis scale** – if this check box is selected the scale on the X-axis managed by the software automatically, as data accumulate;
- **(05) Automatic Y axis scale** – if this checkbox is selected the scale on the Y-axis is managed by the software automatically, as data accumulate, and depending on maximum of the concentration values;
- **(06) Y axis max** – maximum value on the Y-axis. The field is enabled if the **Automatic Y axis scale** checkbox is not selected;
- **(07) Current loop, max C value (20 mA)** – maximum concentration, which corresponds to 20 mA current value;
- **(08) Current loop, min C value (4 mA)** – minimum concentration, which corresponds to 4 mA current value.

- **(09) Standard pressure, kPa** – atmospheric pressure [kPa], with respect of which measured mercury concentration value is recalculated;
- **(10) Standard temperature, °C** – temperature [°C], with respect of which measured mercury concentration value is recalculated.

Changing the parameters values on the other tabs is prohibited until password is preliminary entered. If it is necessary to change the value of any unavailable parameter, please contact the technical support service of the Manufacturer.

2.8 Shut-Down Procedure

2.8.1 Regular Shutdown

- terminate **Lumex Observer** software by the TERMINATE button in the screen
- terminate Windows by standard procedure with the help of a mouse, the stylus or with your finger
- after Windows is closed, move Power switch to off position

3 Operating Modes

3.1 ZERO CONTROL Mode

In ZERO CONTROL mode, either process gas is passed through a special filter **HgF** which removes all mercury, or mercury-free zero gas is admitted via the FILTER INLET at the rear of the Monitor. The Monitor routinely checks and adjusts its zero level once every 5 min for 1 min. During this time the average concentration value of the last 4 min will continue to be transmitted to the central immission control computer.

ZERO CONTROL can also be started by a command from the external process control computer under the Gesytec protocol.

3.2 CALIBRATION Mode

In CALIBRATION mode, the monitor determines a new calibration coefficient. CALIBRATION starts with a zero check as described under 3.1. After that, the calibration cell is moved into the light path of the spectrometer for 20 sec, and the average response S_{cell} and the temperature T of the cell are measured. From these data, the new calibration coefficient A is calculated as

$$A = k * C_{sat}(T) / S_{cell},$$

where k = constant = l_{cal} / L_{anal} (l_{cal} – length of light path in the calibration cell, L_{anal} – length of light path in the multipath cell.)
$C_{sat}(T)$ – concentration of saturated mercury vapour in the calibration cell at temperature T.

The new calibration coefficient A is saved and used to calculate the analytical results until the next calibration.
Finally, another zero check is run, and the monitor switches back to MEASURING mode.

The Monitor automatically repeats calibration in accordance with the value of the parameter **(01)** ***Interval between calibration, h*** on the User tab of the Parameters window (see Fig. 2.5).

CALIBRATION can also be started by a command from the external process control computer under the Gesytec protocol.

3.3 MEASURING Mode

Measuring procedure provides for estimation of the concentration average value within the time set by the Manufacturer. Calculating the concentration average value is performed with respect to changing the zero level of the analytical signal within the measuring time (zero drift).
The concentration value corrected on two sequential procedures of zero reading is displayed on the monitor screen, is transferred to the external computer and is also saved to the monitor memory in the <**results.dat**> file.

3.4 SERVICE Mode

The Monitor operates in SERVICE Mode during Start-up procedure (see 2.6) and during automatic system tests after a failure has been detected.

Analytical data continue to be sent to the central immission control computer but the status signal SERVICE renders them invalid.

Error codes and screen messages of the software:

Error description	**Screen message**	**Binary code**	**Decimal code**
No failures		00000000	0
Lamp failure	LOW light	00000001	1
Calibration cell failure	ERROR: CALIB cell	00000010	2
Valve failure	ERROR: SAMPLE valve	00000100	4
Analytical cell temperature out of range: 10 – 45 C°	ERROR: ANAL T	00001000	8
Calibration cell temperature out of range: 10 – 45 C°	ERROR: SPEC TEM	00010000	16
Flow rate out of range: 4 - 15 l/min	ERROR: FLOW	00100000	32
Analytical cell pressure out of range: 65 – 115 kPa	ERROR: ANAL P	01000000	64
Concentration out of range: > 2 000 ng/m^3		10000000	128

4 Maintenance and Service

The Monitor is performing self-checks in regular intervals. In case of failure, the Monitor will transmit an error code to the process control system. In such case, the Lumex service engineer should be called.

It is recommended to have preventive maintenace done by a qualified service engineer twice per year.

If maintenance or repair work has to be performed on the Monitor power should be switched off.

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In Europe:
Lumex Analytics GmbH

Address: Naher Str. 8,
D-24558
Wakendorf II

Phone: +49 4535 297756
Fax: +49 4535 297783

E-mail: info@lumexanalytics.de
Web: www.lumexanalytics.de

Worldwide:
Lumex Ltd.

Address: 70/2, pr. Obuhovskoy Oborony
St. Petersburg 192029
Russian Federation

Phone: +7 812 718 5390
Fax: +7 812 718 5399

E-mail: sales@lumex.ru
Web: www.lumex.ru