

**X-RAY AND GAMMA RADIATION PERSONAL DOSIMETER
PM1621M (PM1621MA)
OPERATING MANUAL**

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This manual is intended to describe the design, operation and use of the X-ray and gamma radiation personal dosimeter PM1621M (PM1621MA) (hereinafter referred to as the device or instrument).

The Operating Manual includes the general description, specifications of the instrument, as well as other information necessary for the proper operation of the instrument and understanding of device capabilities.

Changes may be made to the instrument electrical scheme, construction, design and software that do not influence the specifications and, therefore, may be not specified in this manual.

1 DESCRIPTION AND OPERATION OF THE INSTRUMENT

1.1 Application of the instrument

The PM1621M (PM1621MA) X-ray and gamma radiation dosimeter is designed to provide:

- continuous measurement of the personal dose equivalent (hereinafter referred to as dose equivalent or DE) of external gamma and X-ray (hereinafter photon) radiation $H_p(10)$;
- continuous measurement of the time DE accumulation;
- continuous measurement of the personal dose equivalent rate of external photon radiation $\dot{H}_p(10)$ (hereinafter dose equivalent rate or DER);
- search, detection and localization of gamma radiation sources;
- communication of information accumulated and stored in the device's non-volatile memory through an infra-red (IR) communication channel (the protocol is compatible with IrDA interface) into a personal computer (PC) using an internal or external IR adapter.

Instruments may be used independently or as a part of a system for everyday, efficient and emergency dosimetric control of personnel, production facilities and units where there is a potential or real risk of exposure to external X-ray and gamma radiation. Customs and border officers, personnel of nuclear facilities; radiological and isotope laboratories; officers of the emergency services; civil defense, fire brigades, police, as well as in other spheres where measurement of personal dose equivalent and personal dose equivalent rate will be notified by an alarm when the preset dose and dose rate levels are exceeded. Information about the dose accumulation and dose rate over time, as well as association of the measured parameters with an individual makes systematization and complex analysis of the accumulated dosimetric information feasible.

Operating conditions:

- ambient air temperature from minus 40°C up to plus 60°C;
- relative humidity up to 98 % at the temperature 35°C;
- pressure from 84 up to 106,7 kPa.

1.2 Delivery kit

1.2.1 Delivery kit of the instrument is specified in the table 1.1.

Table 1.1

Item	Quantity, pcs.
X-ray and gamma radiation dosimeter PM1621M (PM1621MA)	1
CD Disk with "System of Data Collection and Processing for the 1621/1603/1604 Devices" software	1
Operating manual	1
Package	1
Alkaline AA-type battery (PANASONIC POWER LINE LR6 or similar) ²⁾	1
Accessories: ¹⁾	
Infrared communication kit	1
Pouch ¹⁾	1
Alkaline AA-type battery (Energizer L91BP-2 or similar) ³⁾	1
¹⁾ Available as an option by special order. ²⁾ Used within the temperature range of minus 20 – plus 60 °C. Usage of other batteries with similar parameters is allowed. ³⁾ Used within the temperature range of minus 40 – plus 60 °C. Usage of other batteries with similar parameters is allowed.	

1.3 Specifications

1 Operating mode:	<ul style="list-style-type: none"> - indication of photon radiation DER; - indication of photon radiation DE; - indication of the instrument's number; - PC data exchange; - search; - indication of the audible alarm; - indication of the vibration alarm; - set mode; - indication of partial and critical battery discharge; - audible, vibration and visual (blinking red LED) alarming at exceeding of the preset DE or DER thresholds.
2 DER measurement range: - for the PM1621M modification - for the PM1621MA modification - DER indication sub-range	0.1 μ Sv/h - 100 mSv/h; 0.01 μ Sv/h – 2.00 Sv/h. 0.01 – 9.99 μ Sv/h; 10.0 – 99.9 μ Sv/h; 100 - 999 μ Sv/h; 1.00 – 9.99 mSv/h; 10.0 – 99.9 mSv/h; 100 - 200 mSv/h; 100 - 999 mSv/h (PM1621MA); 1.00 – 2.00 Sv/h (PM1621MA).
- DER analogue scale (seven segments) in a logarithmic gauge	Number of indicated segments (from left to right) corresponds to the following DER threshold values on the LCD display: <ul style="list-style-type: none"> - one segment - $\geq 0.1 \mu$Sv/h; - two segments - $\geq 1 \mu$Sv/h; - three segments - $\geq 10 \mu$Sv/h; - four segments - $\geq 100 \mu$Sv/h; - five segments - ≥ 1 mSv/h; - six segments - ≥ 10 mSv/h; - seven segments - ≥ 100 mSv/h.
3 Maximum permissible intrinsic relative error of DER measurement	$\pm(15 + K_1/\sqrt{\text{`}} + K_2 \sqrt{\text{`}}) \%$, where ` - DER value, mSv/h; K_1 – coefficient 0.0015 (mSv/h); K_2 – coefficient $0.01 (\text{mSv/h})^{-1}$.
4 DE measurement range Maximum permissible intrinsic relative error of DE measurement	1.0 μ Sv - 9.99 Sv; $\pm 15 \%$.
5 DE indication range Indication sub-ranges:	0.01 μ Sv – 9.99 Sv. 0.01 – 9.99 μ Sv; 10.0 – 99.9 μ Sv; 100 – 999 μ Sv; 1.00 – 9.99 mSv; 10.0 – 99.9 mSv; 100 - 999 mSv; 1.0 – 9.99 Sv.

-
- 6** Discreteness of DE accumulation time indication 1 h.
-
- 7** The instrument provides inputting, storage in a non-volatile memory and continuous control of two threshold DER and DE levels within the whole measurement range. When the preset first and second DER and DE alarm threshold levels are exceeded the instrument produces audible, vibration and visual (blinking red LED) signals.
Discreteness of threshold level setting Unit of lower-order indicated position.
-
- 8** Registered energy range 0.01 – 20 MeV.
Energy response relative to 0.662 MeV (^{137}Cs) (see Attachment D), no more than $\pm 30\%$.
-
- 9** Anisotropy (see Attachment C) of the device for each energy does not exceed values (in %) presented in Table 1.2, when the device is rotated in the horizontal plane (Attachment B, figure B.1) and values (in %) presented in Table 1.3, when the device is rotated in the vertical plane (Attachment B, figure B.2).

Table 1.2

Angle of detection relative to the direction of graduation, °	Energy of gamma radiation, MeV		
	Anisotropy		
	0.059	0.662	1.25
0	0	0	0
15	± 5	± 5	± 5
30	± 10	± 10	± 10
45	± 20	± 15	± 15
60	± 40	± 20	± 20
-15	± 5	± 5	± 5
-30	± 10	± 10	± 10
-45	± 20	± 15	± 15
-60	± 40	± 20	± 20

Table 1.3

Angle of detection relative to the direction of graduation, °	Energy of gamma radiation, MeV		
	Anisotropy		
	0.059	0.662	1.25
0	0	0	0
15	± 5	± 5	± 5
30	± 10	± 10	± 10
45	± 20	± 15	± 15
60	± 40	± 20	± 20
-15	± 5	± 5	± 5
-30	± 10	± 10	± 10
-45	± 20	± 15	± 15
-60	± 40	± 20	± 20

-
- 10** Coefficient of variation (deviation of the instrument's readings caused by statistic fluctuations) at DER measurement at a confidence coefficient 0,95, no more than $\pm 15\%$.
-

<p>11 Maximum permissible additional relative error of DER measurement:</p> <ul style="list-style-type: none"> - at temperature variations from minus 40 to plus 60°C - at relative humidity of ambient air 98 % at 35 °C - at power voltage variations from nominal value to limiting voltage values - on exposure to magnetic field of 400 A/m strength - on exposure to radio frequency electromagnetic fields of 10 V/m strength 	<p>±10 %;</p> <p>±10 %;</p> <p>± 10 %;</p> <p>± 5 %;</p> <p>± 5 %.</p>
<p>12 LCD backlight at pressing LIGHT/SET button</p>	<p>3-5 s.</p>
<p>13 Instability of readings during 24 hour continuous work, no more than</p>	<p>± 5 %.</p>
<p>14 Response time (according to IEC 61526), when DER value is increased more than 10 times from initial DER value to finite fixed high DER value exceeding 10 μSv/h, no more than</p>	<p>5 s.</p>
<p>15 Response time(according to IEC 61526) when DER value is decreased more than 10 times, from initial high to finite fixed low DER value exceeding 10 μSv/h, no more than</p>	<p>10 s.</p>
<p>16 PC communication</p>	<p>- by special software using IR communication channel adapter.</p>
<p>17 In the PC data exchange mode the instrument provides the following functions:</p>	<p>1) permission or prohibition of the following operating modes (parameters) of the instrument:</p> <ul style="list-style-type: none"> - DER indication; - indication of DER coefficient of variation; - indication of DER averaging time; - DE indication; - indication of DE accumulation time; - indication of time remaining for stay at the working place depending on the current measured DER and DE values; - indication of the instrument's number; - audible alarm; - preset of the DE and DER threshold levels using the buttons; - DE reset using the buttons.

		<p>2) read-out of the following information from the instrument to PC:</p> <ul style="list-style-type: none"> - instrument's parameters; - DER history and DE accumulation (date, time, event, value); - DE (DER) values at the moment of exceeding the preset thresholds as well as time, date and month of exceeding the preset thresholds; - values of the preset DE and DER thresholds; - official information <p>3) recording of the following information from PC to instrument:</p> <ul style="list-style-type: none"> - instrument's parameters; - values of DE and DER thresholds; - interval of DER history and DE accumulation recording; - current time and date for forming DE accumulation history; - official information.
18	In the search mode the instrument provides the following functions:	<ul style="list-style-type: none"> - turn on/ off the search mode; - detection and localization of photon radiation sources by change in frequency of audible, vibration and visual alarms; - indication the search mode ON/OFF.
19	In the mode of indication of the audible alarm the instrument provides the following functions:	<ul style="list-style-type: none"> - turn on/off the audible alarm; - indication of turning ON/OFF of the audible alarm; - sound pressure level control and indication in the analog (scale) and digital formats (from 1 to 4).
20	In the mode of indication of the vibration alarm the instrument provides the following functions:	<ul style="list-style-type: none"> - turn on/off the vibration alarm; - indication of turning ON/OFF of the vibration alarm.
21	Power supply	1.5 (+ 0.1; minus 0.4) V (one AA type battery).
22	<p>Period of continuous operation of the instrument from one battery, using LCD backlight not more than 5 s/day, audible alarm – not more than 20 s/day and at an average value of the measured DER up to to 0.3 μSv/h:</p> <ul style="list-style-type: none"> - at a temperature from 0 up to 60°C - at a temperature minus 40, at least: 	<p>12 months;</p> <p>6 months.</p>
23	Protection degree of the instrument's case	IP67 .

24	The instrument is proof against:	<ul style="list-style-type: none"> - temperature of an ambient air from minus 20⁰C up to plus 60⁰C with indication of measurement results on LCD; - temperature of an ambient air from minus 40 up to minus 20⁰C without indication of measurement results on LCD but with recording of measurement results in a non-volatile memory; - relative humidity of an ambient air up to 98 % at 35⁰C; - atmosphere pressure from 84 up to 106,7 kPa.
25	The instrument is proof against:	<ul style="list-style-type: none"> - sinusoidal vibration in the frequency range 10 – 55 Hz and bias amplitude for frequencies lower than the transition frequency 0.35 mm; - shocks with acceleration 100 m/s², duration of shock pulse 2-50 ms, shock rate is 60 - 180 shocks per minute.
26	The instrument meets drop test against a concrete surface from the height	0,7 m.
27	The instrument is proof against static and variable magnetic fields of strength	up to 400 A/m.
28	The instrument is proof against the action of radio frequency electromagnetic fields in the frequency range 26 – 1000 MHz of strength	up to 10 V/m.
29	The instrument in a transport package is proof against:	<ul style="list-style-type: none"> - temperature from minus 50 up to plus 50⁰C; - humidity up to 100 % at 40⁰C; - shocks with acceleration 98 m/s², duration 16 ms; - vibrations with frequency 10-55 Hz and bias amplitude 0.35 mm.
30	Weight (with battery) Weight in package	no more than 0.16 kg. no more than 0.3 kg.
31	Dimensions	87x72x35 mm.
32	Reliability parameters: - average full operating time - average service life - average time of recovery	no less than 20000 h; no less than 10 years no more than 60 min.

Note – For additional information about instrument, please visit www.polimaster.com.

1.4 Design and theory of operation

1.4.1 The instrument comprises the following main blocks and modules: radiation detector; microprocessor; LCD; secondary power supply; IR-transceiver; and non-volatile memory.

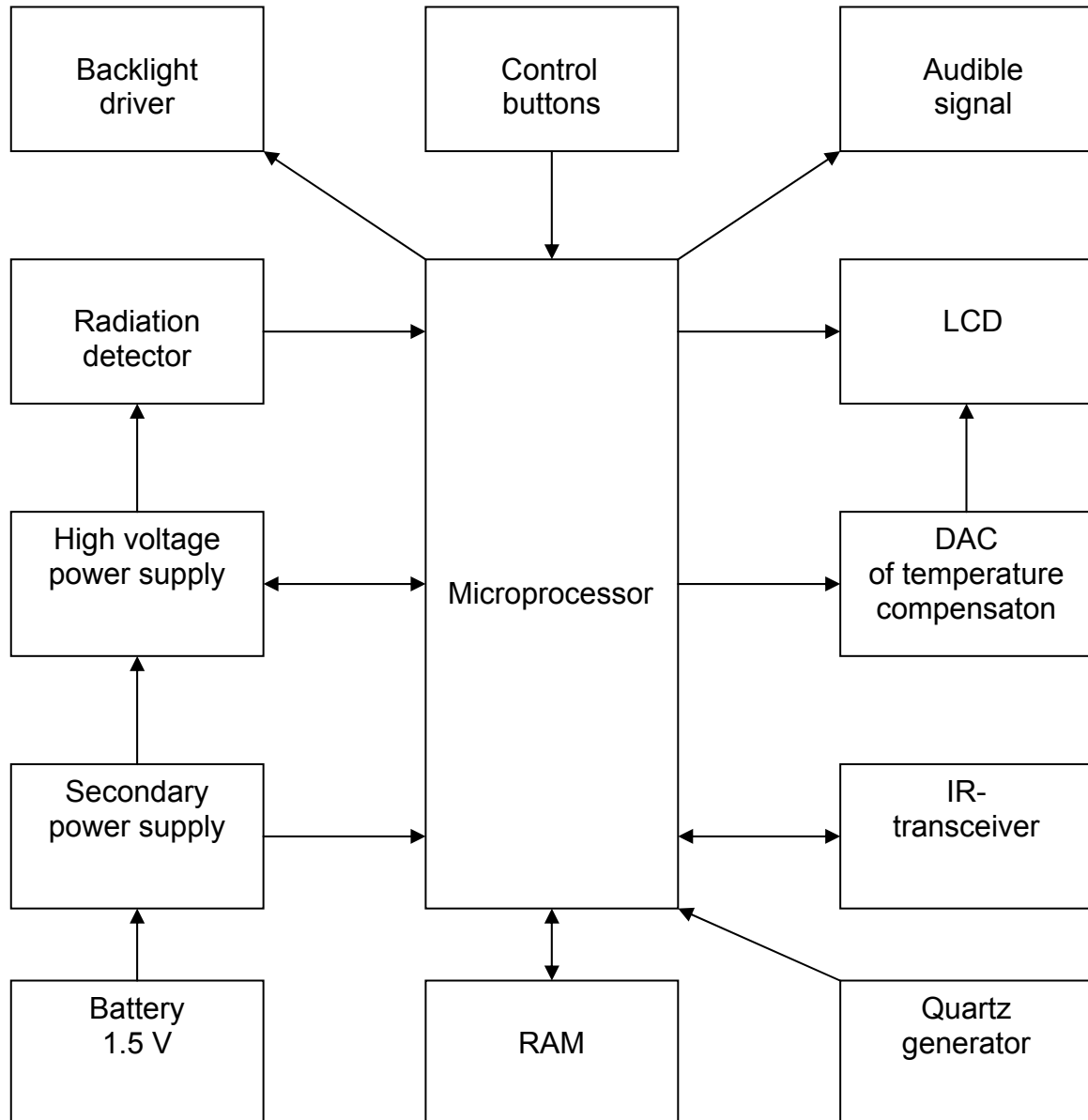


Figure 1.1 – Block diagram of the instrument

A Geiger-Muller tube with a filter for spatial-energy formation of sensitivity, which converts photon radiation quanta to electric pulses, is used as a radiation detector. The detector has a high-voltage power supply.

The microprocessor controls the instrument's operating modes, backlight device, audible, vibration and visual alarm devices, infrared communication channel, LCD, non-

volatile memory, high-voltage power supply of the detector, operates the control buttons, performs all the necessary calculations, self-diagnostics.

The instrument's operating algorithm ensures continuity of the measurement process, statistical processing of the measurement results, a prompt adaptation to the variation of level of the photon radiation dose rate (setting the time of measurement in inverse dependence on the dose rate) and effective output of the information obtained to the LCD. The IR-communication channel provides an exchange of information with PC.

The instrument has an internal non-volatile memory that allows the information accumulation and storage.

Secondary power supply provides transformation of the battery's voltage 1.5. V into a stable voltage 3 V necessary for the instrument's power supply.

1.4.2 The device is designed as a unit housed in a plastic shock-proof case. General overview of the instrument and its parts is given in Figure 1.2. Indication elements, positions **1 - 4**, are displayed on the LCD (**8**).

1 – DER analog scale (seven segments) for effective control over radiation situation, analog scale (four segments) for indication of sound pressure level in search mode.

2 – DER digital panel in DER indication mode, DE in DE indication mode, instrument's number, indication of IR communication channel switch on/off in the PC data exchange mode, indication of search mode switch on/off.

3 – digital panel of the coefficient's of variation indication in percents in DER indication mode, DE accumulation time's indication in thousands of hours (h) in DE indication mode, indication of production month and year in the instrument's number indication mode;

4 – digital panel of indication of time of averaging DER values (in seconds) in DER indication mode, of DE accumulation time in DE indication mode; sound pressure level (from 1 to 4) in search mode

5 – the **LIGHT** button for switching on LCD backlight, switching on PC data exchange mode, entering the set mode and exiting it (see item 2.1.6).

6 – the **MODE** button for selecting the instrument's indication mode (DER, DE, the instrument's number, PC data exchange);

7 – LED of visual alarm;

8 – LCD;

9 – IR-transceiver window;

10 – detector;

11 – Battery compartment cover.

A direction of calibration and the detector effective center relative to which the factory calibration is performed are placed at a 15 mm distance from the instrument detector's surface (Appendix B).

The total surface density of the walls surrounding the detector is 1 g/cm² that provides the detector shielding from the background beta radiation.

The PM1621M is provided with a clip and may be fasten to the belt. The clip may be removed using a screwdriver (see Fig.1.3). A carrying pouch is also available as an option.

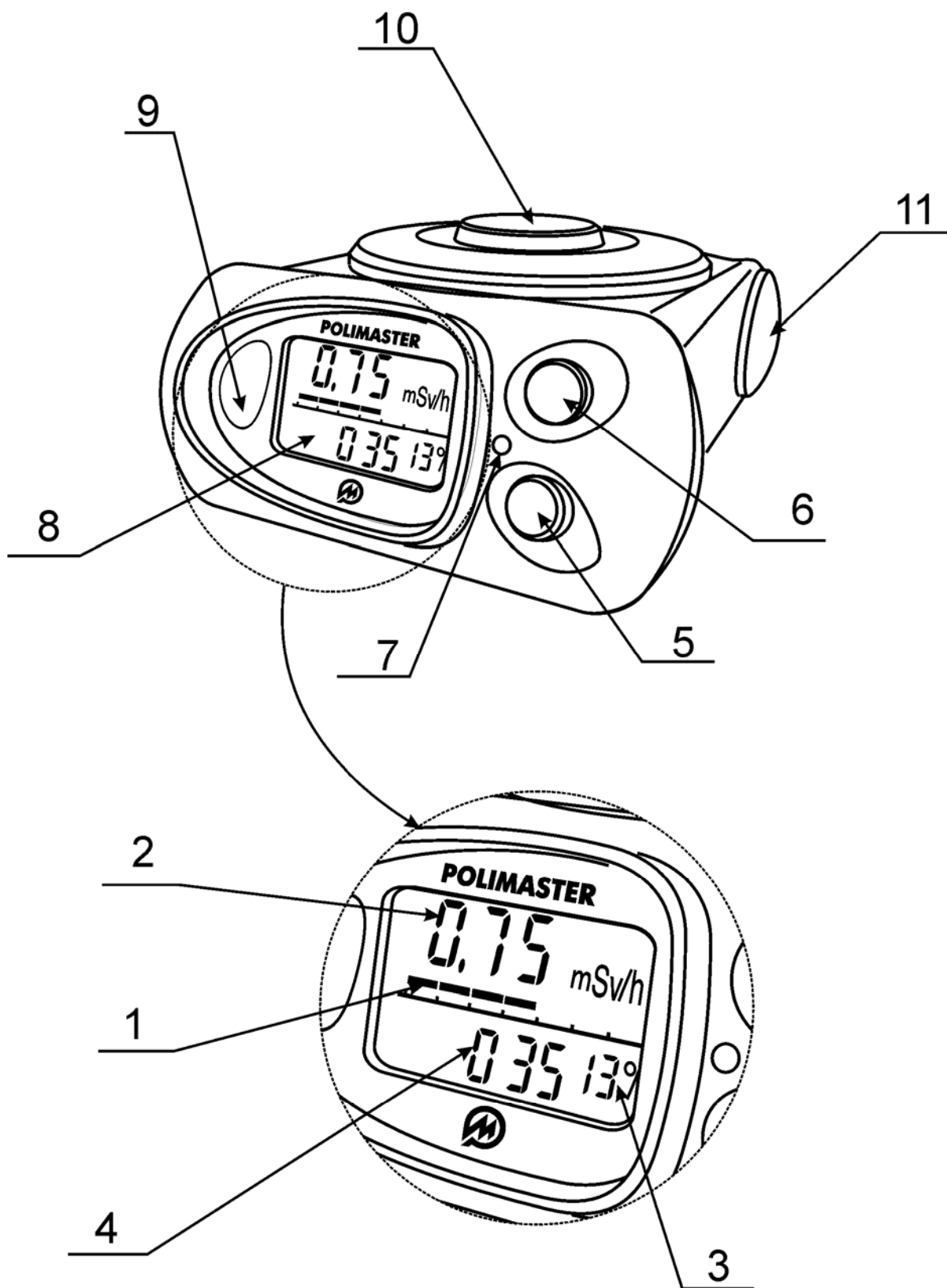


Figure 1.2 – General overview of the instrument

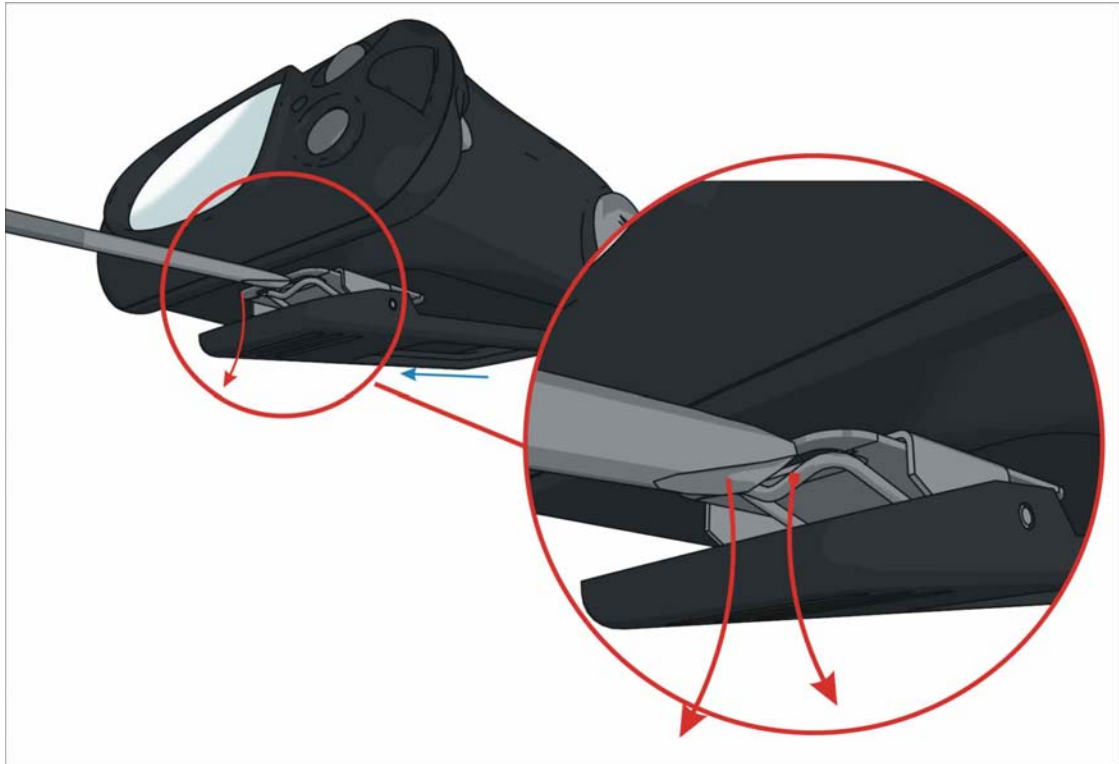


Figure 1.3 - The PM1621M with a removable clip

2 USE OF THE INSTRUMENT

2.1 General guidelines

When you receive the device after purchase please check the delivery kit and confirm proper operation of the device in all the operation modes as outlined in sections 2.4.3 to 2.4.5.

Protect the device from shocks and mechanical damages. Avoid exposing the device to hostile environments, organic solvents and open fire.

2.2 Safety instructions

During device adjustment, checking, repair, maintenance and verification always follow your employer's protocols for work with radioactive materials and other radiation sources, as well as accepted standards for radiation safety.

2.3 Preparation for use

2.3.1 Please read all sections of the manual before using the device.

2.3.2 Unpack the instrument.

2.3.3 Switching on:

- unscrew the battery compartment's cover;
- insert the battery into the compartment making sure that the positive (“+”) end of the battery is inserted first;
- replace the battery compartment's cover.

Right after inserting the battery the dosimeter performs LCD testing (all the segments and graphic symbols will display for about 2 seconds and then disappear), then the dosimeter should enter the measurement mode. One minute after inserting the battery the dosimeter is ready for use.

2.3.4 Place and fix the instrument, detector outwards, on a breast pocket of overalls or inside it or on the belt.

Attention! If the device is expected to be used under conditions when the dose rate value is higher than 0.1 mSv/h, it is recommended to insert a fresh battery.

2.4 Use of the instrument

2.4.1 The instrument operates in the following modes:

- photon radiation DER indication mode;
- photon radiation DE indication mode;
- number indication mode;
- mode of data transmission to PC;
- search mode;
- audible alarm indication mode;
- vibration alarm indication mode;
- set mode;
- partial or critical battery discharge indication mode;
- audible, vibration and visual alarm mode when exceeding preset DE or DER thresholds.

The following values will be stored in the instrument's non-volatile memory during the task of replacing the battery:

- accumulated dose (DE);
- DE accumulation time;

- DE and DER accumulation history;
- the preset DER and DE thresholds.

When using the instrument in a temperature range from -40°C up to -20 °C the device provides performance of the dosimetric functions without displaying the result of measurement on LCD. When the instrument is returned to a temperature higher than -20 °C LCD operates in a normal way.

The instrument performs continuous DER and DE measurement, DE accumulation time counting in all modes, excluding an active mode of data transmission to PC (on/Ir).

Standard configuration of the instrument as includes the following parameters and functions:

DER Indication Mode - On

- Figure 1.2, Item 2 - DER values output.
- Figure 1.2, Item 3 - output of the coefficient of variation values – Off.
- Figure 1.2, Item 4 - output of DER values averaging – Off.
- Thresholds setting enable: - Off Audible alarm:
Off.

DE Indication Mode - On

- Figure 1.2, Item 2 - DE values output.
- Figure 1.2, Item 3 - Output of DE accumulation time values in thousands hours (symbol **h** is indicated at DE accumulation time less than a thousand hours).
- Figure 1.2, Item 4 - Output of DE accumulation time values in hours -
On
- Figure 1.2, Item 4 - Output of values of time remaining for staying at the
working place - Off.
- Thresholds setting enable - On DE reset – On.
- Audible alarm - On.

Number Indication Mode - On

- Figure 1.2, Item 2 - Dosimeter's number.
- Figure 1.2, Item 3 - Month of the dosimeter's production.
- Figure 1.2, Item 4 - Year of the dosimeter's production.
- Audible alarm - On.

Search mode - On.

Audible alarm indication mode - On.

Vibration alarm indication mode - On.

2.4.2 Selection of an indicated parameter

DER, DE, **instrument's** number and data transmission to PC modes are switched on by a successive pressing of the MODE button (Figure 2.1, Item 6).

The dosimeter allows for switching all the above-mentioned indication modes on and off. Change of the configuration is performed in data transmission to PC mode.

2.4.3 DER indication mode

In the DER mode (figure 2.1) the following values appear on the LCD:

- DER ($\mu\text{Sv/h}$, mSv/h , Sv/h);
- DER on the analogue scale in a logarithmic gauge (seven segments);
- coefficient of variation in percents;
- averaging time of DER values (Range of the averaging time indication is from 1 up to 2999 s. If the averaging time exceeds 2999 s, the symbols “- - -” appear on the LCD).

If the measured DER value is over the upper limit of the DER indication range (200 mSv/h for the PM1621M and 2 Sv/h for the PM1621MA), the LCD will show the overload symbol “**OL**” and the interrupted sound signal is formed.

In the DER mode the collected statistics of DER measurement can be cleared and measurement reactivated by simultaneously pressing the LIGHT + MODE buttons.

2.4.4 DE indication mode

In the DE mode (figure 2.1) the following values are indicated on the LCD:

- DE (μSv , mSv , Sv);
- DE accumulation time.

DE and DE accumulation time can be reset in the set mode by simultaneously pressing the LIGHT+MODE buttons (Figure 2.2).

In the mode of data transmission to PC it is possible to set an inhibit for DE reset using the buttons.

There are two method of measurement of the DE accumulated over a certain period of time.

The first method (recommended). In the beginning of measurement the DE should be reset using the keys or the PC and the program “System of date collection and processing for the 1621 device.” Then the dose displayed at the end of the period will be the dose accumulated over the period of measurement.

The second method. The dose value in the beginning of the period of measurement should be deducted from the DE value displayed at the end of the period.

In the DE mode the indication (Figure 1.2, items 3 and 4) of values of time remaining for staying at the working place depending on the current measured DER and DE values is possible. Calculation of time is performed relative to the second preset DE threshold (the function may be switched on at the DE indication mode configuration).

2.4.5 Set mode

Auxiliary set mode (figures 2.2, 2.3) is meant for verification and (or) setting of the threshold DE (DER) values, DE and DE accumulation time reset.

Attention! To enter the “set” mode press and hold for about 5 s the LIGHT button and the parameter to be set will be flashing.

To chose the parameter press and release the **LIGHT** button.

Press and hold the MODE button to rapidly change the parameter.

Press and release the MODE button to change the parameter to an exact setting. Press and hold the SET button to exit the “set” mode or the dosimeter will automatically exit set mode in approximately 90 seconds.

Inputting the DER (DE) threshold levels into the memory

This procedure can be performed in the DER (DE) measurement mode as well as in of data transmission to PC mode. DER (DE) thresholds are input during DER (DE) indication on the LCD.

Enter the set mode by pressing and holding the SET button (Figures 2.2, 2.3). Input the first and then the second threshold levels. Exit the set mode. In data transmission to PC mode it is possible to set an inhibit for changing the threshold levels using the buttons. In case of exceeding the value of the first (second) DER (DE) threshold, the dosimeter turns correspondingly into the DER (DE) indication mode and noncontinuous (frequent noncontinuous) audible signal will sound. When the DER value drops below the preset threshold, the audible signal will shut off. Press any button to silence the alarm sound. The audible signal will shut off automatically in approximately 60 seconds, the repeated audible signal will sound in approximately 4 minutes.

2.4.6 Number indication mode

In **number** indication mode the following items appear on the LCD:

- the instrument's number on a display (Figure 2.1, Item 2);
- year (Figure 2.1, Item 4) and month (Figure 2.1, Item 3) of production.

2.4.7 Data transmission to PC mode

2.4.7.1 The instrument allows storage and transmission to PC of DE history (hereinafter "history"), DER accumulation, events of exceeding the preset DE and DER threshold values, event of DE reset through IR communication channel using the buttons.

Selection of the events to be stored in the history, and frequency of these recordings is performed using software. History data are inaccessible without IR adapter (internal or external).

The instrument performs data transmission to PC under the software program "System of Data Collection and Processing for the 1621/ 1603/ 1604 Devices" through the IR communication channel adapter compatible with IrDA interface.

Minimum computer system requirements:

- Pentium 100;
- 32 Mb RAM;
- monitor resolution 800 x 600;
- IR adapter (internal or external);
- OS Windows 98/2000/XP;
- printer.

2.4.7.2 To use the dosimeter in data transmission to PC mode:

- Read and follow the recommendations of the file Read_me.doc on the CD supplied with IR adapter;
- Read the help file Help_ 1621.doc;
- Connect the adapter of IR communication channel to a PC COM port;
- Install the IrDA communication unit and switch on the IR connection;
- Install the program "System of Data Collection and Processing for the 1621/1603/1604 Devices" from the CD, (run the program \DISK1\SETUP.EXE);
- Run the program 16XX.EXE;
- Read the help section of the program "System of Data Collection and Processing for the 1621/ 1603/ 1604 Devices";
- Orient the dosimeter and adapter of IR communication channel of the PC by placing the dosimeter at a distance of 10-20 cm from the IR channel adapter;

- Choose the mode of data transmission to PC using the MODE button;
- Press and release the LIGHT/SET button for PC link startup through IR channel;
- Perform readout of the dosimeter's information following the program's instructions.

2.4.7.3 Permission or prohibition of the following operating modes (parameters) of the dosimeter:

- DER indication;
- Indication of DER coefficient of variation;
- Indication of DER averaging time;
- DE indication;
- Indication of DE accumulation time;
- Indication of time remaining for stay at the working place depending on the current measured DER and DE values;
- Indication of the dosimeter's number;
- Audible alarm;
- Preset of the DE and DER threshold levels using the buttons;
- DE reset using the buttons.

2.4.7.4 Read-out of the following information from dosimeter to PC:

- Dosimeter's parameters;
- DER history and DE accumulation (date, time, event, value);
- DE (DER) values at the moment of exceeding the preset thresholds as well as time, date and month of exceeding the preset thresholds;
- Values of the preset DE and DER thresholds;
- Official information.

2.4.7.5 Recording of the following information from PC to dosimeter:

- Dosimeter's parameters;
- Values of DE and DER thresholds;
- Interval of DER history and DE accumulation recording;
- Current time and date for forming DE accumulation history;
- Official information.

2.4.8 Search mode

In search mode instrument can detect and locate the gamma radiation source. For this purpose it is necessary to turn on the search mode.

How to turn on the search mode shown in Figure 2.1

When the first DER alarm threshold is exceeded (source detection), the source is closer, the rate of audible, visual and vibration signals will be increased. When the maximum frequency level is achieved, the device will produce continuous audible, vibration and visual alarm.

To optimize the location of a gamma source, press shortly the SET button. The rate of audible, visual and vibration alarms will decrease. When the SET button is pressed secondary, the rate of audible, visual and vibration alarms will be set default values.

When the second DER alarm threshold is exceeded, the device will produce frequent interrupted audible, visual and vibration alarms.

To locate the gamma radiation sources, the device should be placed in such manner that the detector effective center (Figure 1A) should be directed to scanned object and be kept on the 10 cm distance from the object. The velocity should be no more than 10 cm/min.

Number "1" and one line indicate the lower sound pressure level, "4" and four lines are for higher sound pressure level.

2.4.9 Audible alarm indication mode

In the audible alarm indication mode (Fig. 2.1) the instrument provides the following functions:

- turn on/off the audible alarm;
- indication of turning ON/OFF of the audible alarm;
- sound pressure level control (Fig. 2.4) and indication in the analog (scale) and digital formats (from 1 to 4);

The level 1 (one line) corresponds to the minimal sound level. The level 4 (four lines) corresponds to the maximal sound level.

2.4.10 Vibration alarm indication mode

In the vibration alarm indication mode (Fig. 2.1) the instrument provides the following functions:

- turn On/Off vibration alarm;
- indication of turning On/Off of the vibration alarm.

2.4.11 Partial or critical battery discharge indication mode

The instrument checks battery discharge once every 10 minutes.

If the battery has been partially discharged (approximately 1.1 V) the LCD will flash the symbol "bat".

In case of the battery **critical discharge** (approximately 0.9 V) the instrument will turn into the DE indication mode, the symbol "bat" will become solid, the instrument will stop the measurements, LCD backlight and audible alarm will become locked.

The battery is to be replaced! (see 3.3).

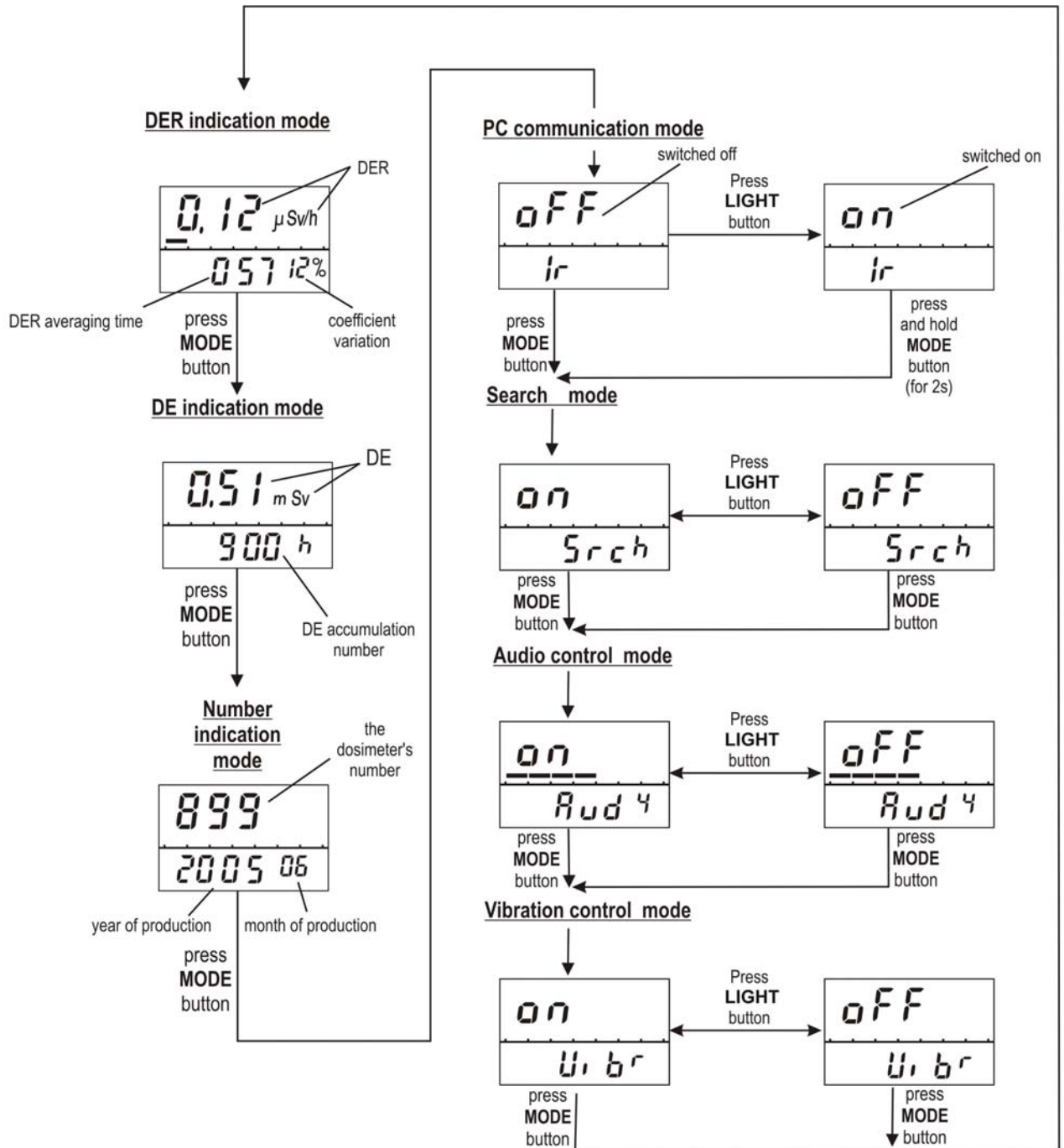


Figure 2.1 - Choice of operating mode (indication) of the instrument

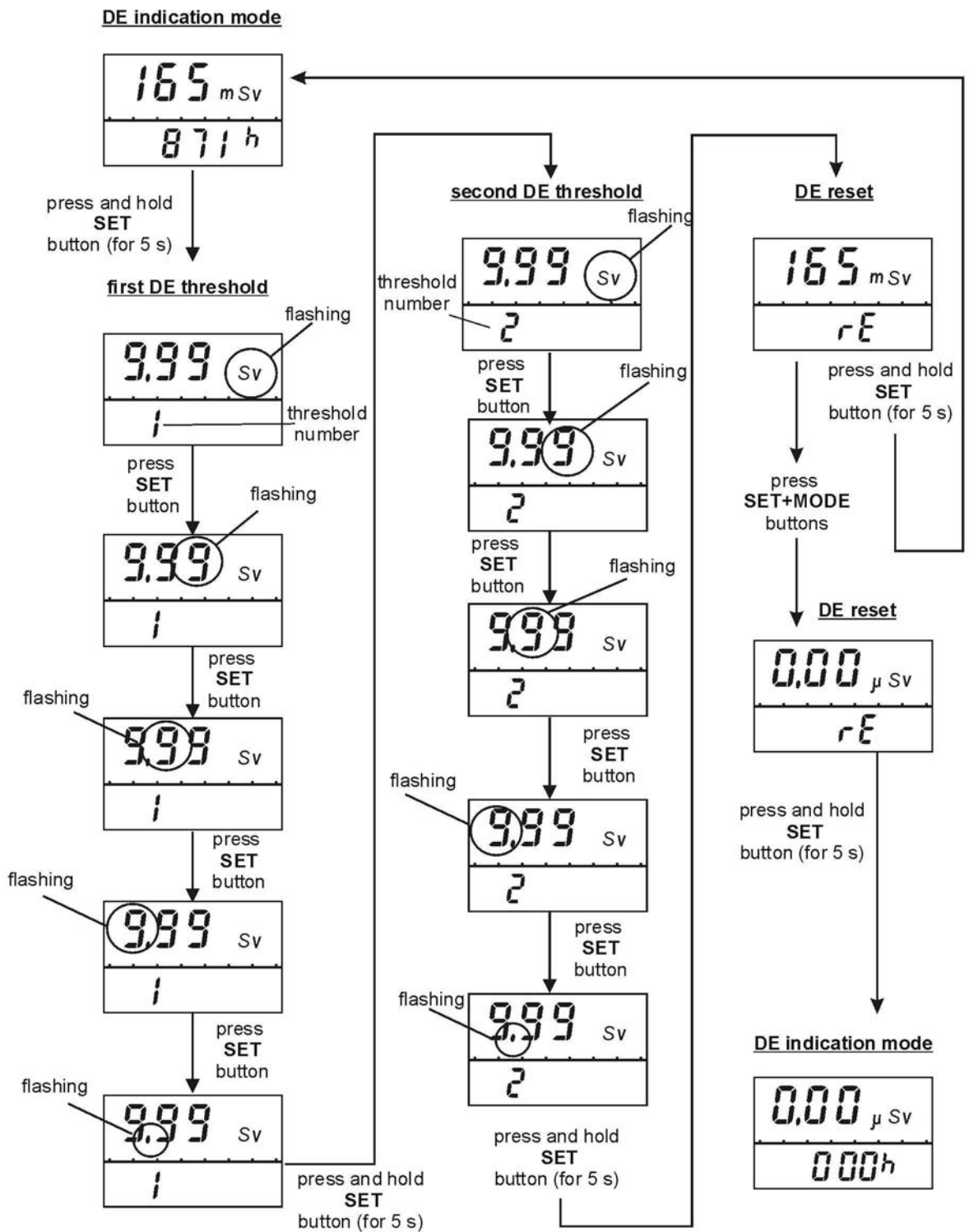


Figure 2.2 - Setting the DE threshold values

DER indication mode

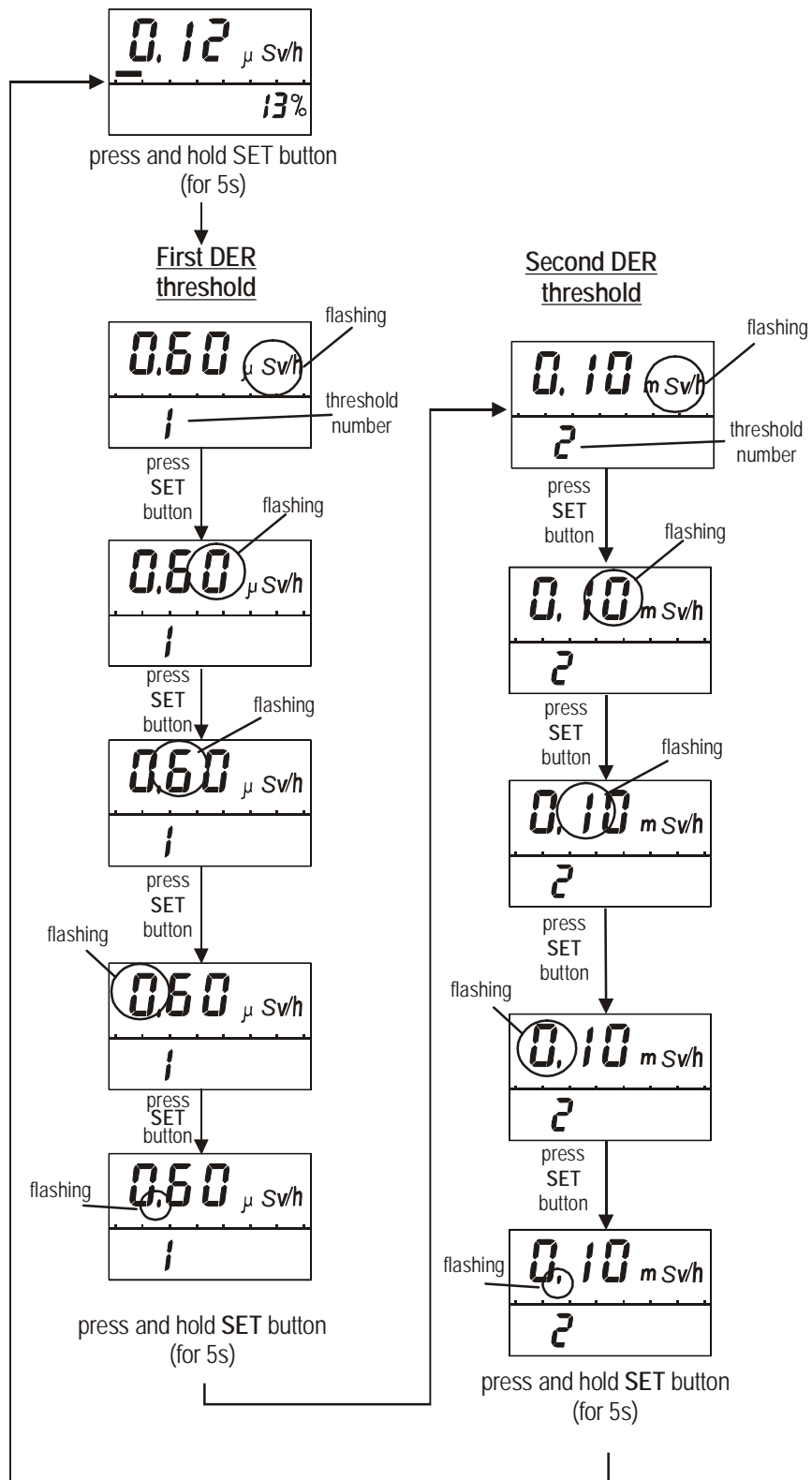


Figure 2.3 - Setting the DER threshold values

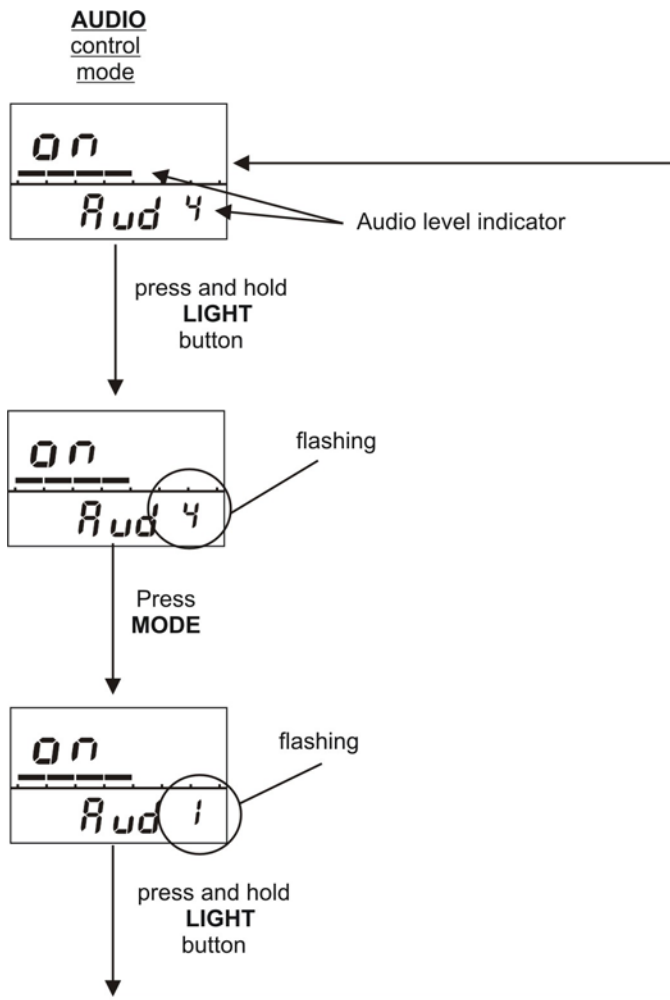


Figure 2.4 – Audio control mode
(control of the sound volume)

3 MAINTENANCE

3.1 Maintenance involves preventive services, battery replacement and regular performance check (according to 2.4.3 - 2.4.5).

3.2 Preventive services include external examination, dusting and decontamination in the event of radioactive contamination.

For decontamination wipe the case of the instrument using a cloth wetted with ethanol.

3.3 Battery replacement:

- unscrew and remove the cover of the battery compartment;
- remove the old battery;
- insert the battery into the compartment making sure that the positive (“+”) end of the battery is inserted first;
- replace the battery compartment cover.

After the battery is replaced, the LCD will display all segments, and then the instrument should enter the measurement mode. All the previous measurements and parameters necessary for proper operation of the instrument are stored in its non-volatile memory.

NOTE - Insert a new battery before sending a instrument for calibration.

4 TROUBLESHOOTING

The list of possible problems and their solutions are specified in the table 4.1.

Table 4.1

Problem	Possible cause	Solution
1 The LCD indicates “bAt” message	Battery discharge	Replace the battery
2 No indications on the LCD	Battery discharge Battery is inserted incorrectly	Replace the battery Insert the battery correctly
3 The device does not respond to pressing a button, the LCD indicates incorrect symbols	Microprocessor error condition	Remove the battery and insert again after 5 minutes
4 The LCD indicates Er1- Er7	Instrument failure	Return instrument for repair

Note – If a defective battery is used the Er1 – Er7 message may appear.

Attention! When the Er1 – Er7 message appear, press any button. When the error message appears for the second time (approximately in 15 minutes) the instrument is not to be used.

5 STORAGE AND SHIPPING

5.1 Packaged devices may be shipped by any method of closed transport at the air temperature from -50 °C to +50 °.

5.2 Packaged devices should be secured during transport.

5.3 When carried by sea, packaged devices should be sealed in plastic bags with silicagel.

5.4 When carried by air, packaged devices should be placed in sealed compartments.

5.5 Devices should be stored in the manufacturer's package at an air temperature ranging from -15 to +50°C and relative humidity ranging from -15 to +50°C and relative humidity up to 95% at a temperature of 35°C.

5.6 Devices without package should be stored at an air temperature from 10 to 35°C and relative humidity up to 80% at a temperature of 25°C.

5.7 The storage location should be free of dust, chemical vapors, aggressive gases and other substances that may cause corrosion.

6 WARRANTY

6.1 The manufacturer guarantees that the device meets the requirements of Technical Conditions provided that the customer will observe the guidelines of its use, shipping and storage described in this manual.

6.2 The warranty period of use is 18 months from the date of sale.

6.3 Warranty and after-warranty repair is carried out by the manufacturer or the institutions that have a permission of the manufacturer.

6.4 Warranty does not cover the devices:

- without the operating manual;
- in case of their unauthorized opening;
- with mechanical damages;
- if the requirements of exploitation and storage were not satisfied;

6.5 The warranty period of use is prolonged for a period of warranty repair.

6.6 Warranty does not cover battery replacement.

ATTACHMENT A
(reference)

OVERALL DIMENSIONS, EFFECTIVE CENTER OF THE INSTRUMENT DETECTOR

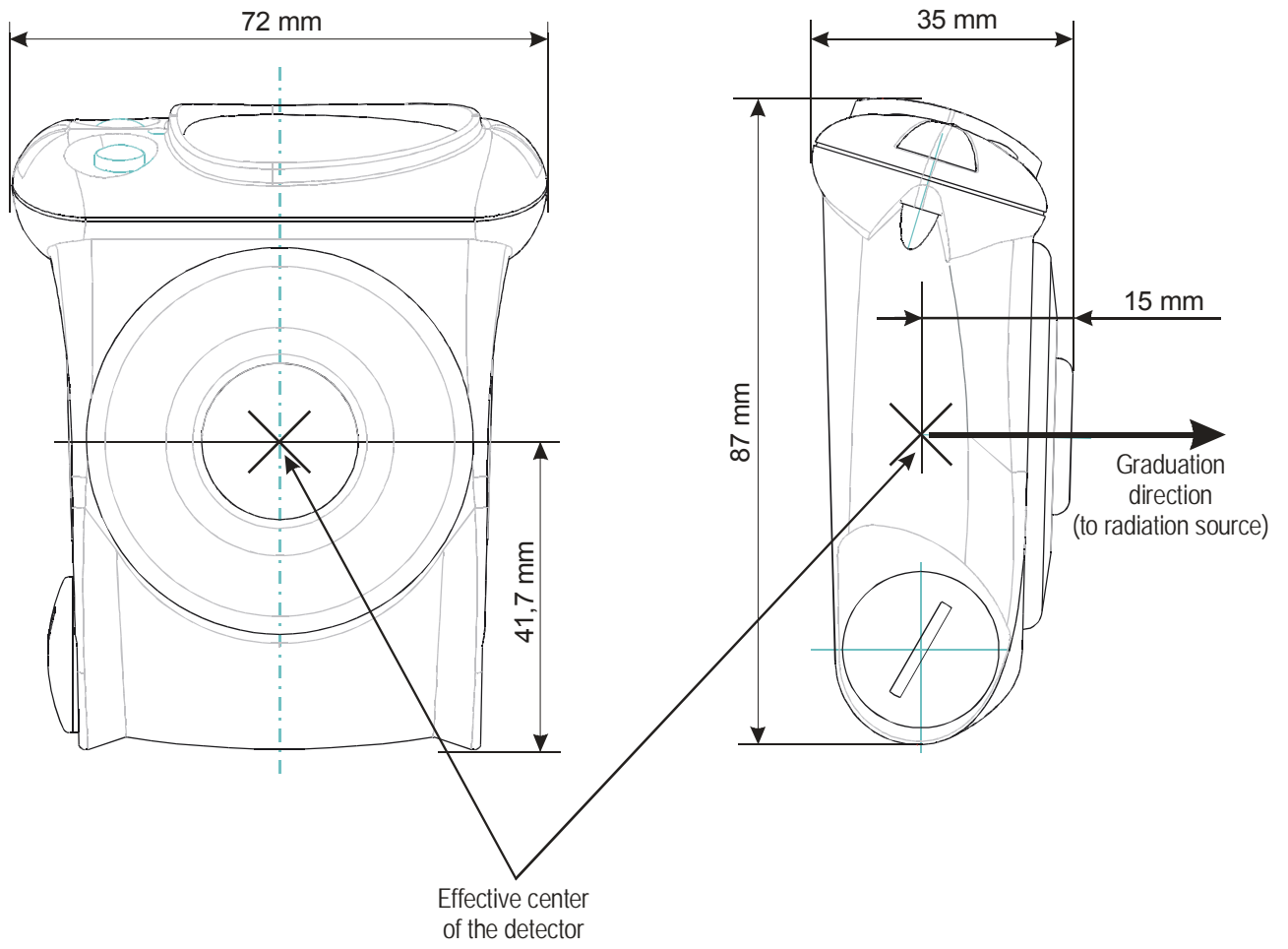


Figure A.1

ATTACHMENT B
(reference)
DIAGRAM OF INSTRUMENT ROTATION TO MEASURE ANGULAR RESPONSE

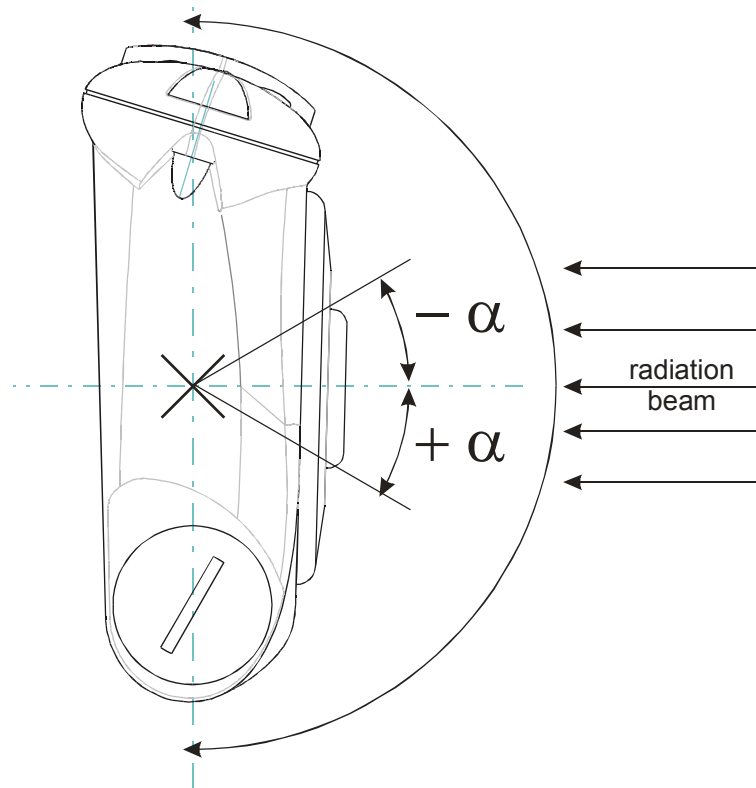


Figure B.1 –Diagram of instrument rotation in horizontal plane

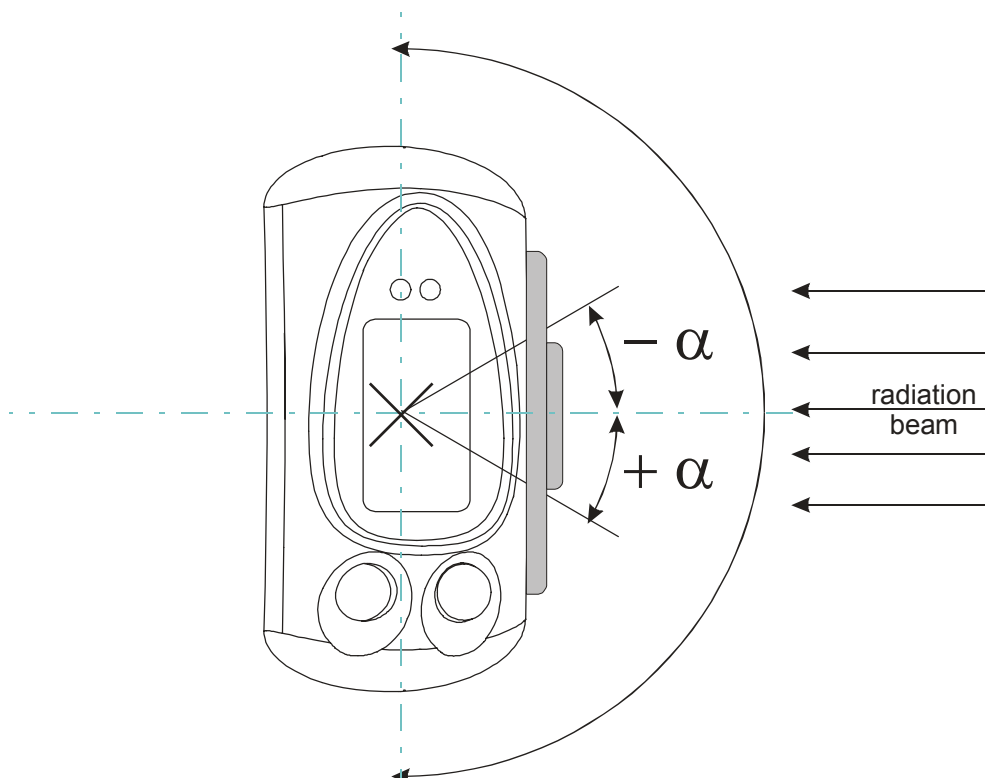


Figure B.2 –Diagram of instrument rotation in vertical plane

ATTACHMENT C

(reference)

Typical instrument anisotropy

(data are normalized to the calibration direction 0°)

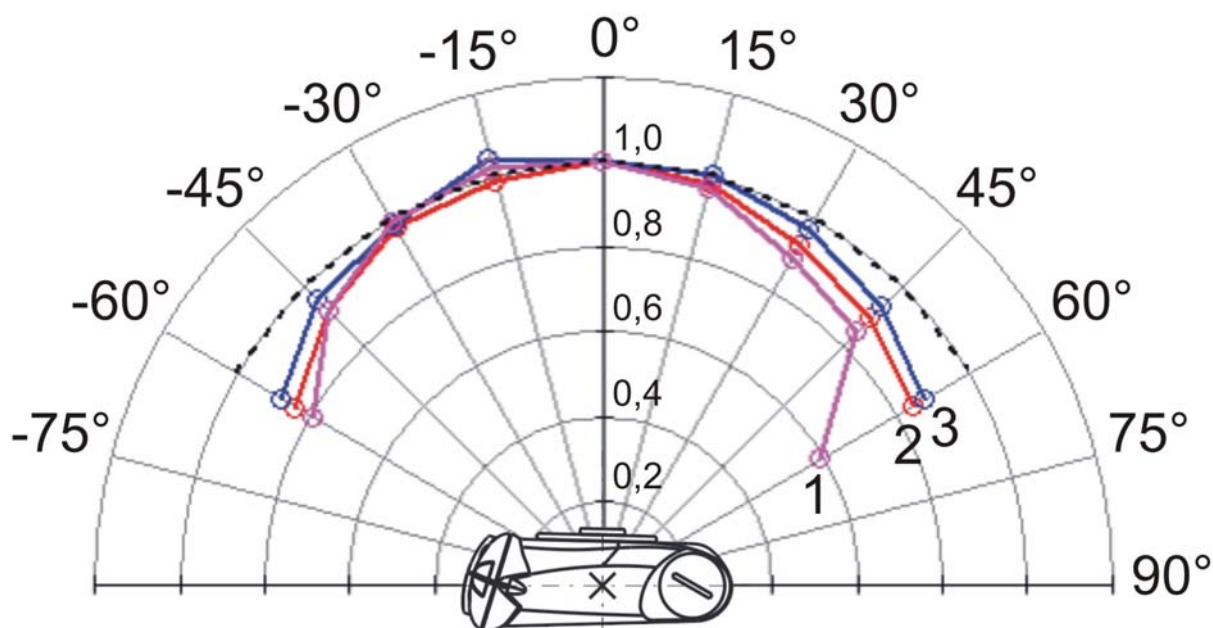


Figure C.1 – for horizontal installation at the phantom (rotation in vertical plane):
1 – ^{241}Am (59,5 keV); 2 - ^{137}Cs (662 keV); 3 - ^{60}Co (1250 keV)

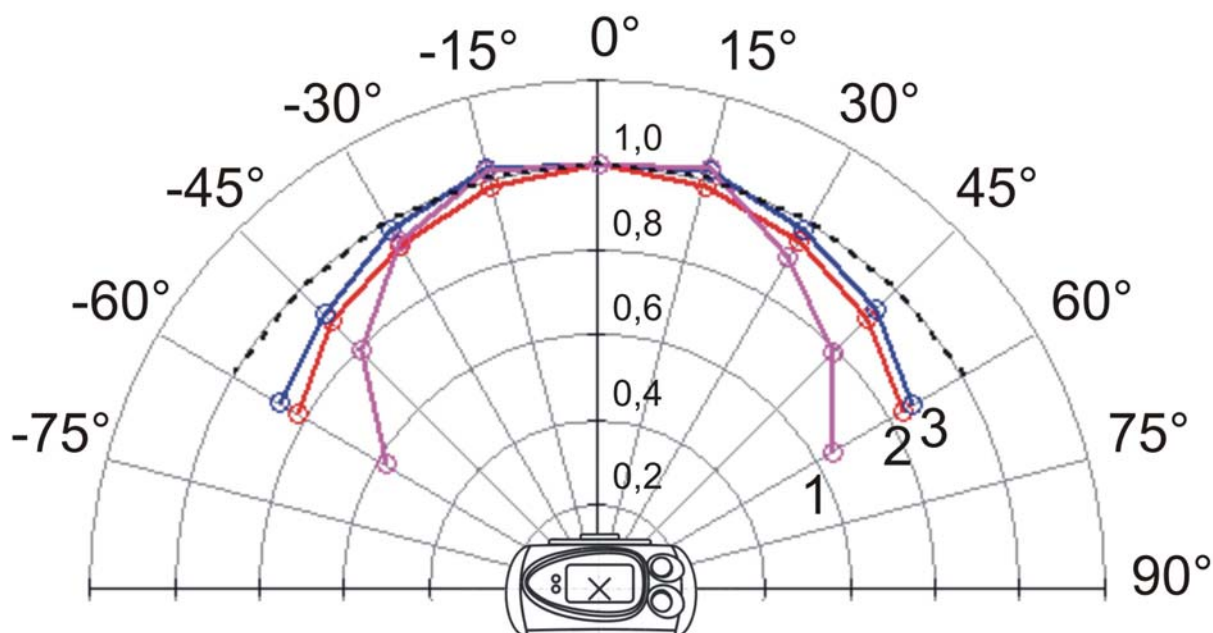


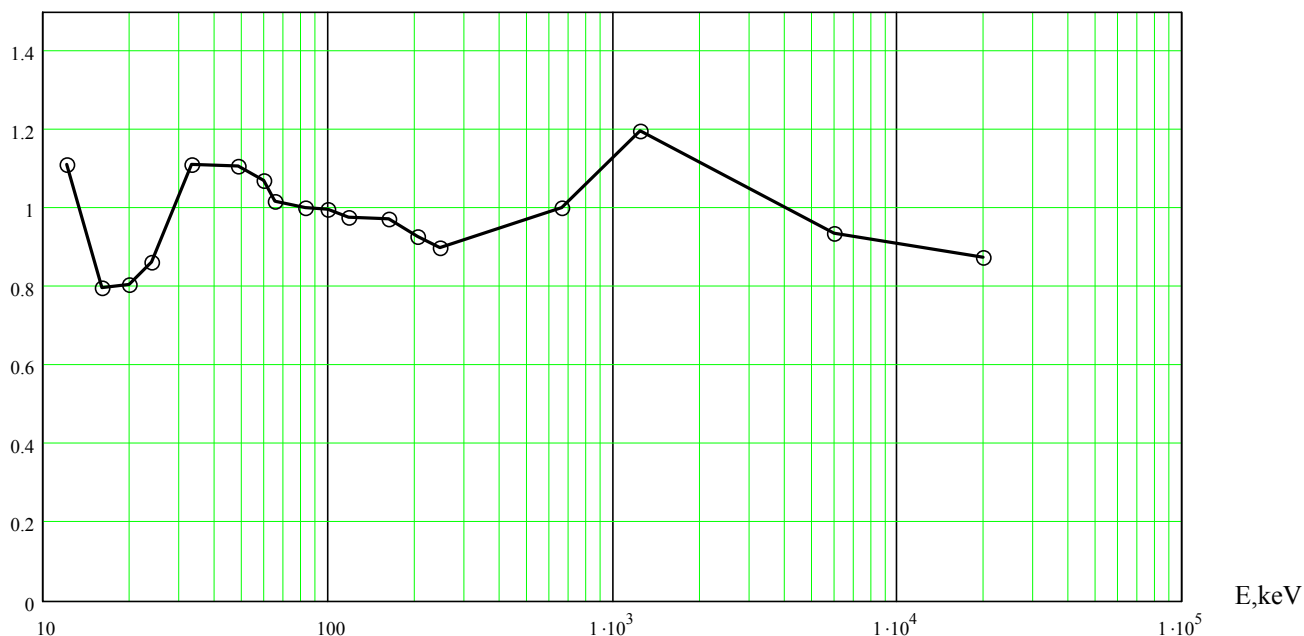
Figure. C2 – for vertical installation at the phantom (rotation in horizontal plane):
1 – ^{241}Am (59,5 keV); 2 - ^{137}Cs (662 keV); 3 - ^{60}Co (1250 keV)

ATTACHMENT D

(reference)

Typical instrument energy dependence relative to the energy 662 keV of ¹³⁷Cs gamma radiation

$$\frac{Hp(10),(E)}{Hp(10), (662 \text{ keV})}$$



E, keV	12	16	20	24	33	48	59.5	65	83	100	118	164	205	248	662	1250	6000	20000
$\frac{Hp(10),(E)}{Hp(10), (662 \text{ keV})}$	1.11	0.79	0.81	0.86	1.11	1.10	1.07	1.02	1	0.99	0.98	0,97	0.92	0.89	1	1.19	0.94	0.88

Figure D.1 - Typical instrument energy dependence relative to the energy 662 keV of ¹³⁷Cs gamma radiation $Hp(10),(E)/Hp(10)$