PERSONAL COMPACT DOSIMETER
PM1604A (PM1604B)
OPERATING MANUAL

CONTENTS

This Operating Manual is intended to describe the design, operation and use of personal compact dosimeter modification PM1604A and modification PM1604B (hereinafter referred to as dosimeter). The Operating Manual includes the general description, specifications of the dosimeter, instructions for the use of the dosimeter, instructions for metrological test, maintenance recommendations, as well as some other information necessary for the proper operation of the dosimeter and a full realization of its possibilities.

The name of the dosimeter in technical documentation and in order is as following: “Personal Compact Dosimeter PM1604A”, “Personal Compact Dosimeter PM1604B ”.

During manufacturing of the dosimeter some changes may be introduced in its electrical scheme and construction that do not influence the specifications and metrological parameters and, therefore, may be not specified in this manual.

1 DESCRIPTION AND OPERATION OF THE DOSIMETER

1.1 Application of the dosimeter

The PM1604A(B) personal compact dosimeter is designed to provide:

- continuous measurement of the personal dose equivalent rate of external gamma and X-ray radiation $\dot{H}_p(10)$ (hereinafter referred to as dose equivalent rate or DER);

- measurement of the personal dose equivalent of external gamma and X-ray radiation $H_p(10)$ (hereinafter referred to as dose equivalent or DE);

- measurement of the DE accumulation time;

- indication of current time in hours, minutes and seconds;

- indication of date and month;

- using as alarm clock, timer, stop-watch;

- communications of information accumulated and stored in a non-volatile memory through infra-red (IR) communication channel (the protocol is compatible with IrDA interface) into the personal computer (PC) using the internal or external IR adapter.

The dosimeters may be used independently or as a part of a dosimetric control system for everyday, efficient and emergency dosimetric control of the personnel and people at sites, production facilities and units, where there is a potential or real risk of exposure to external X-ray and gamma radiation by officers of customs and border services, personnel of nuclear facilities, radiological and isotope laboratories, officers of the emergency services, civil defense, fire brigades, police, as well as in other spheres of use where there is a necessity in measurement of the personal dose equivalent and personal dose equivalent rate, alarming of the exceeding of the preset dose and dose rate levels, information about the dose accumulation and conduct of the dose rate in time, as well as association of the measured parameters with an individual, systematization and complex analysis of the accumulated dosimetric information.

The dosimeter is manufactured in two modifications:

- the PM1604A personal compact dosimeter;
- the PM1604B personal compact dosimeter, differs from the PM1604A dosimeter by an extended range of DER measurement.

Operating conditions:

- ambient air temperature from minus 30 up to plus 70^{o} C;
- relative humidity up to 98 % at the temperature 35^{o} C;
- pressure from 84 up to 106.7 kPa.

1.2 Delivery kit

1.2.1 Delivery kit of the dosimeter corresponds to the table 1.1.

Table 1.1

Item	Type	Quantity, pcs.	
		PM1604A	PM1604B
Personal compact dosimeter PM1604A	412118.032	1	-
Personal compact dosimeter PM1604B	412118.032	-	1
Infrared communication kit [1)]	426434.011	1	1
Battery [2)]	RENATA CR2032	1	1
Disk	305555.007	1	1
Operating manual	412118.032 РЭ	1	1
Verification technique of personal compact dosimeters[3)]	1118-2002	1	1
Package	412915.037	1	1

[1)] -Available as an option.
[2)] - Usage of other batteries with similar parameters is allowed.
[3)] -It is included in Operating Manual, Attachment A (available on order)

1.3 Specifications

1	Operating mode:	- indication of gamma radiation DER; - indication of gamma radiation DE; - indication of the dosimeter's number; - PC data exchange; - alarm clock; - timer; - stop-watch; - clock-calendar; - set mode; - indication of partial and critical battery discharge; - audible alarming at exceeding of the preset DE or DER thresholds
2	DER measurement range	
	- for the PM1604A modification	1 μSv/h – 5.0 Sv/h
	- for the PM1604B modification	1 μSv/h – 10.0 Sv/h
	DER indication range:	
	- for the PM1604A modification	0.01 μSv/h – 6.50 Sv/h
	- for the PM1604B modification	0.01 μSv/h – 13.0 Sv/h
	- DER indication sub-range	0.01 – 9.99 μSv/h; 10.0 – 99.9 μSv/h; 100 – 999 μSv/h; 1.00 – 9.99 mSv/h; 10.0 – 99.9 mSv/h; 100 – 999 mSv/h; 1.0 – 6.5 mSv/h (PM1604A); 1.0 – 13.0 Sv/h (PM1604B);
	- 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: - one segment - ≥ 1 μSv/h; - two segments - ≥ 10 μSv/h; - three segments - ≥ 100 μSv/h; - four segments - ≥ 1 mSv/h; - five segments - ≥ 10 mSv/h; - six segments - ≥ 100 mSv/h; - seven segments - ≥ 1.00 Sv/h
3	Maximum permissible intrinsic relative error of DER measurement	±(15 + K_1/` + $K_2$ `) %, where ` - DER value, mSv/h; K_1 – coefficient 0.02 (mSv/h); K_2 – coefficient equal to 0.003 $(mSv/h)^{-1}$ (for the PM1604A modification); K_2 – coefficient equal to 0.002 $(mSv/h)^{-1}$ (for the PM1604B modification);
4	DE measurement range	1.0 μSv - 9.99 Sv

5	Maximum permissible intrinsic relative error of DE measurement in measurement range	± 15 %
6	DE indication range	0.01 μSv – 9.99 Sv
	Indication sub-ranges:	(0.01 – 9.99) μSv; (10.0 – 99.9) μSv; (100 – 999) μSv; (1.00 – 9.99) mSv; (10.0 – 99.9) mSv; (100 – 999) mSv; 1.0 Sv – 9.99 Sv
	DE measurement in the DER value range	0.01 μSv/h – 5.0 Sv/h for the PM1604A modification; 0.01 μSv/h – 10.0 Sv/h for the PM1604B modification;
7	Discreteness of DE accumulation time indication	1 h
8	The dosimeter provides inputting, storage in a non-volatile memory and continuous control of two threshold DER and DE levels within the whole measurement range, various audible alarms at exceeding of the preset first and second threshold levels.	
	Discreteness of threshold DER and DE level setting	Unit of the lower-order indicated position
9	The dosimeter provides the record in the history of DER and/or DE measured values through the programmable time interval with reference to the dosimetric time which is set with the help of PC.	
	The history record	- linear; - iterative (cyclical).
10	Registered energy range	0.048 MeV – 6,0 MeV
	Energy response relative to 0.662 MeV (^{137}Cs), no more than	± 30 % (0.048 MeV – 3,0 MeV); ± 50 % (3.0 MeV – 6,0 MeV)

11 Anisotropy of the dosimeter for each energy value does not exceed values (in %) presented in Table 1.1, when the dosimeter is rotated in the horizontal plane and does not exceed values (in %) presented in Table 1.2, when the dosimeter is rotated in the vertical plane.

Table 1.1

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	±20	±15	±15
30	±20	±15	±15
45	+10…-35	+10…-20	±15
60	+10…-35	+15…-20	±20
-15	±20	±15	±15
-30	±20	±15	±15
-45	+10…-35	+10…-20	±15
-60	+10…-35	+15…-20	±20

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	±20	±15	+10…-15
30	±20	±15	+10…-15
45	+10…-35	±15	+10…-15
60	+10…-35	±15	+10…-15
- 15	±20	±15	+10…-15
- 30	±20	±15	+10…-15
- 45	+10…-35	±15	+10…-15
- 60	+10…-35	±15	+10…-15

12	Coefficient of variation (deviation of the dosimeter's readings caused by statistic fluctuations) at DER measurement at a confidence coefficient 0.95, no more than	±10 %
13	Maximum permissible additional relative error of DER measurement: - at temperature variations from minus 20 to plus 70 °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	 ±10 % ±10 % ± 10 % ± 5 % ± 5 %
14	LCD backlight at pressing LIGHT button	(3-5) s
15	Instability of DER readings during 24 hour continuous work, no more than	5 %
16	The dosimeter has two independent time:	- the current time (clock-calendar), which is set using the buttons; - the dosimeter (inner) time, which is set by the PC
17	In the "clock-calendar" mode the dosimeter provides:	- indication of the current time in hours (24/12), minutes (60), seconds (60); - indication of the week date, number of month, year (automatic calendar);
18	In the "timer" mode of dosimeter provides:	- the set of time intervals from 1s up to 23 h 59 min
19	In the "stop-watch" mode the dosimeter provides:	- the measurement of time intervals in the range from 0.1 s up to 23h 59min 59.9 s
20	Clock daily rate of time gaining or losing in normal conditions, no more than	± 0.5 s

21	PC communication	- by a special program using IR communication channel adapter
22	In the mode of data transmission to PC the dosimeter provides the following functions:	1) permission or prohibition (switch ON/OFF) of the following operating modes (parameters) of the dosimeter: - DER indication; - indication of current time or indication of DER averaging time and DER coefficient of variation; - DE indication; - indication of DE accumulation time; - indication of the dosimeter's number; - alarm clock; - timer; - stop-watch: -clock-calendar; - audible alarm; - preset of the DE and DER threshold levels using the buttons; - DE reset using the buttons. 2) read-out of the following information from the 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 3) 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
23	Power supply	(2,95 $\pm$ 0,25)V (one battery, type CR2032)
24	Period of continuous operation of the dosimeter 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 0.3 μSv/h, at least	9 months
25	Two level control of battery state:	-partial discharge (flashing symbol "BAT"); -critical discharge (non-flashing symbol "BAT")

26	Protection degree of the dosimeter's case	IP67 according to GOST 14254-96
27	The dosimeter is proof against the action of:	- temperature of an ambient air from minus 20 ^{0}C up to plus 70 ^{0}C; - relative humidity of an ambient air up to 98 % at 35 ^{0}C; - atmosphere pressure from 84 up to 106.7 kPa
28	The dosimeter is proof against:	- 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/s^2, duration of shock pulse (2-50) ms, shock rate is 60 - 180 shocks per minute
29	The dosimeter meets drop test against a concrete surface from the height	1.5 m
30	The dosimeter is proof against the action of static and variable magnetic fields of strength	up to 400 A/m
31	The dosimeter is proof against the action of radio frequency electromagnetic fields in the frequency range 80 – 1000 MHz of strength	up to 10 V/m (rigidity degree 3 according to STB GOST R 51317.43-2001)
32	The dosimeter in a transport package is proof against the action of:	- temperature from minus 50 up to plus 50^{0}C; - humidity up to 100 % at 40^{0}C; - shocks with acceleration 98 m/s^2, duration 16 ms; - vibrations with frequency 10-55 Hz and bias amplitude 0.35 mm.
33	Weight, not more than	0.085 kg
	Weight in package, not more than	0.25 kg
34	Overall dimensions, not more than	50x56x19 mm; 50x90x19 mm – with a clip
35	Reliability parameters:	
	- average full operating time, no less than	20000 h
	- average service life, no less than	10 years
	- average time of recovery, no more than	60 min

N o t e – For addition information about dosimeter, please visit **www.polimaster.com**.

1.4 Design and theory of operation

1.4.1. The dosimeter comprises the following main blocks and modules:

- radiation detector;
- microprocessor;
- LCD;
- IR-transceiver;
- non-volatile memory.

The block diagram of the dosimeter is shown in Figure 1.1.

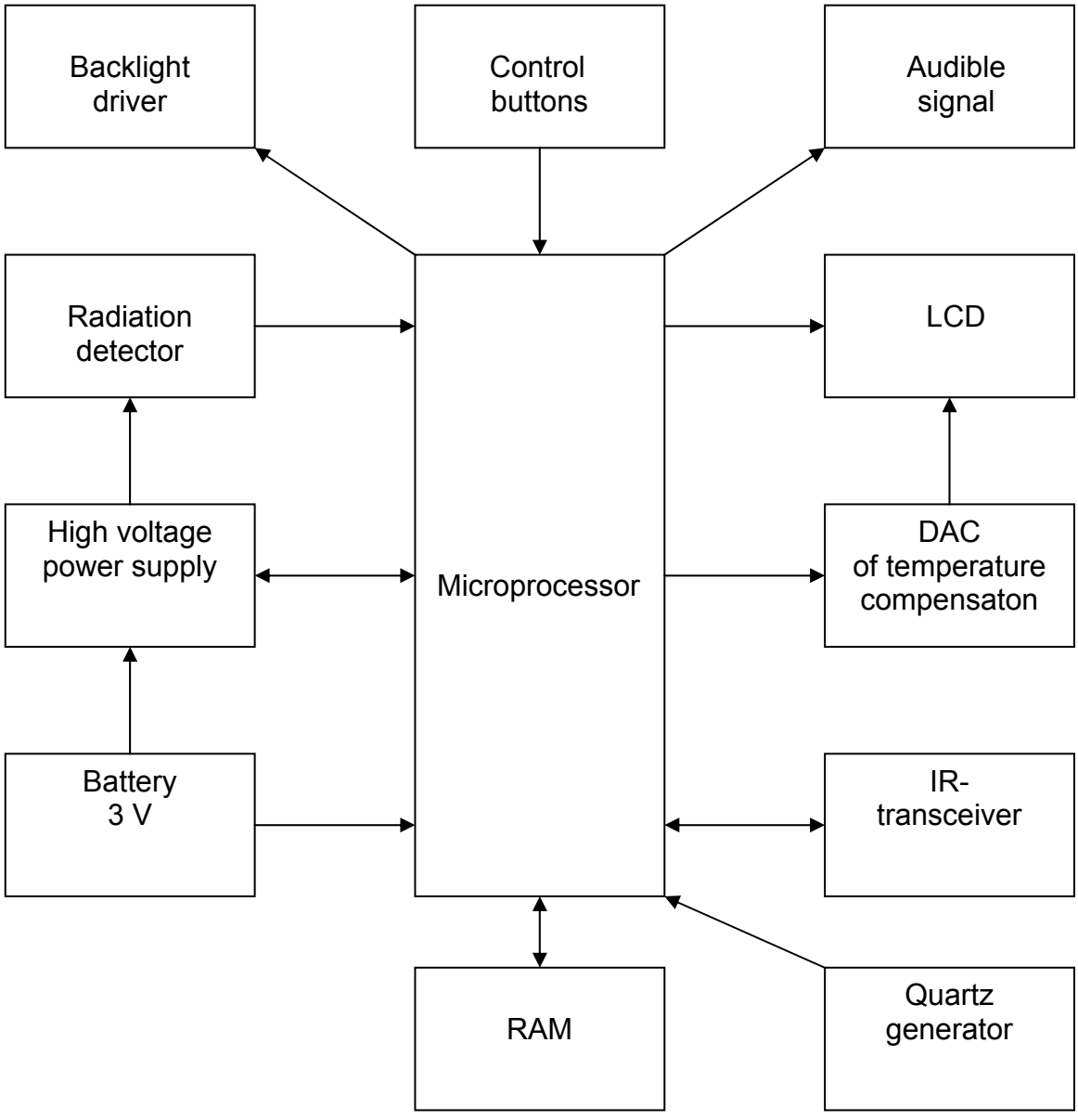

Figure 1.1 – Block diagram of the dosimeter

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

The microprocessor controls the dosimeter's operating modes, backlight device, audible alarm device, 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 dosimeter'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 gamma 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 dosimeter has an internal non-volatile memory that allows the information accumulation and storage.

The dosimeter's non-volatile memory ensures storage of the following parameters when replacing the battery for the moment of the battery's removal:

- accumulated dose (DE);
- DE accumulation time;
- DE and DER accumulation history;
- the preset DER and DE thresholds.

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

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

1 – DER analog scale (seven segments) for effective control over radiation situation;
2 – LCD area, which indicates:

- DER in DER indication mode;
- DE in DE indication mode;
- year of production in the dosimeter's number indication mode;
- IR communication channel switch on/off in the PC communication mode;
- AL symbol in "alarm clock" mode;
- TR symbol in "timer" mode;
- ST symbol in " stop-watch " mode;

3 – LCD area, which indicates the seconds of the current time or the coefficient of variation in DER indication mode, DE accumulation time in thousands of hours (h) in DE indication mode, month of production in the dosimeter's number indication mode;
4 – LCD area, which indicates the hours and the minutes of the current time in DER indication mode or the time of averaging DER values (in seconds) in DER indication mode, DE accumulation time in DE indication mode in hours, the year of production in the dosimeter's number indication mode;
5 – the **SET** button (setting) for switching on PC communication mode, entering the set mode and exiting it (see item 2.1.6);
6 – the **MODE** button for selecting the dosimeter's indication mode (DER, DE, the dosimeter's number, PC communication, alarm clock, timer, stop-watch, clock-calendar);
7 – the **LIGHT** button for switching on LCD backlight;
8 – LCD;

9 – IR-transceiver window.
10 – alarm turn-on symbol;
11 – alarm clock turn-on symbol.

A direction of calibration and the detector effective center relative to which the factory calibration is performed are shown on Figure 1.2. The total surface density of the walls surrounding the detector is 1 g/cm^2 that provides the detector shielding from the background beta radiation.

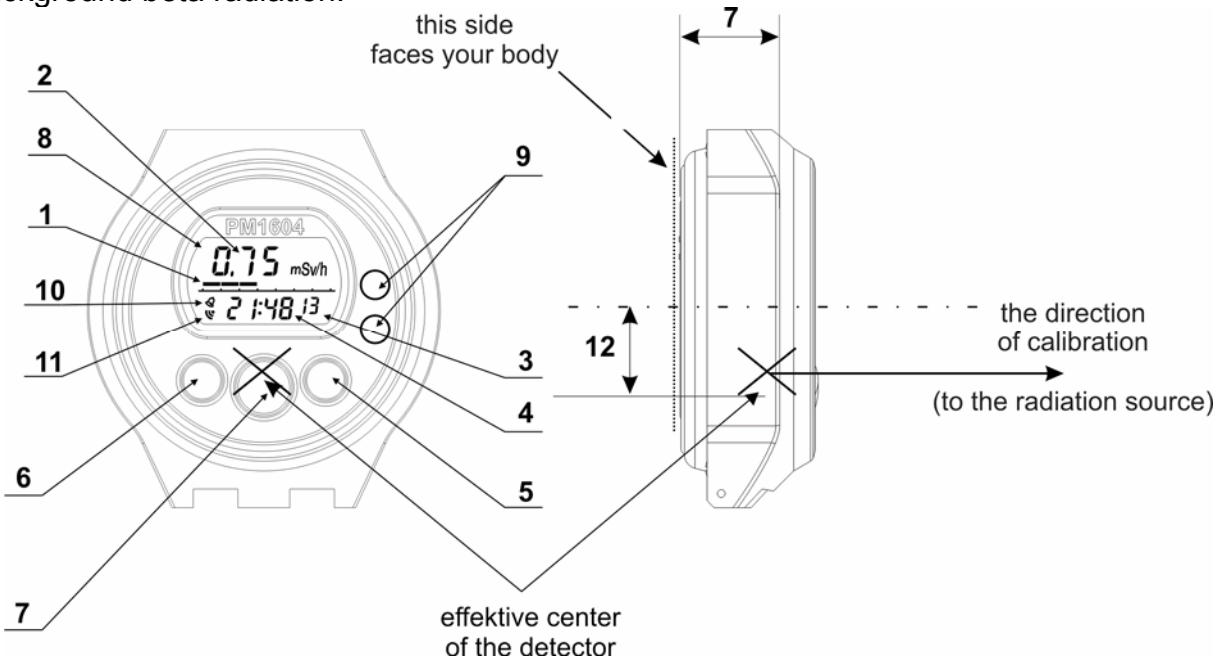

Figure 1.2 – General overview of the dosimeter

2 USE OF THE DOSIMETER

2.1 General guidelines

When purchasing the dosimeter it is necessary to check the delivery kit and the proper operation of the dosimeter in all the operation modes according the items 2.4.2 - 2.4.6.

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

2.2 Safety instructions

During the dosimeter adjustment, checking, repair, maintenance and verification, if the radioactive sources are used, the regulations for work with radioactive materials and other radiation sources, as well as Standards of radiation safety should be followed.

2.3 Preparation for use

2.3.1 It is necessary to study all sections of the present operating manual before using the dosimeter.
2.3.2 Unpack the dosimeter.
2.3.3 Insert the battery in accordance with the section 3.3.
2.3.4 Place and fix the dosimeter on a breast.

N o t e. - If the dosimeter 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 new battery.

2.4 Use of the dosimeter

2.4.1 Selection of an indicated parameter.

The dosimeter operates in the following modes:

- **gamma radiation DER indication mode;**
- **gamma radiation DE indication mode;**
- **dosimeter's number indication mode ("blind dosimeter");**
- **mode of data transmission to PC;**
- **alarm clock;**
- **timer;**
- **stop-watch;**
- **clock-calendar;**
- **set mode;**
- **partial or critical battery discharge indication mode;**
- **audible alarm mode at the exceeding of the preset DE or DER thresholds.**

Modes of DER, DE, dosimeter's number indication' data transmission to PC, alarm clock, timer, stop-watch, clock-calendar are switched on by a successive pressing of the MODE button (figure 2.1).

The dosimeter allows switching on/off all the above-mentioned modes excluding the partial and critical battery discharge indication mode. Change of the configuration is performed in the mode of data transmission to PC.

Standard configuration of the dosimeter when shipping ensures indication of the following parameters and functions performed:

DER indication mode – On (enable)
On a display (2), figure 1.2 – DER values output;
On a display (3) – output of the current time seconds – On (enable);
On a display (3) – output of the coefficient of variation values – Off (disable);
On a display (4) – output of the current time in hours, minutes – On (enable);
On a display (4) – output of DER values averaging – Off (disable);
Thresholds setting enable: - On (enable);
Audible alarm: - On (enable).

DE indication mode – On.
On a display (2), figure 1.2 – DE values output;
On a display (3) – output of DE accumulation time values in thousands hours (symbol "h" is indicated at DE accumulation time less than a thousand hours).
On a display (4) – output of DE accumulation time values in hours – On (enable);
Thresholds setting enable - On (enable);
DE reset - On (enable);
Audible alarm - On (enable).

Dosimeter's number indication mode – On (enable)
On a display (2), figure 1.2 – dosimeter's number;
On a display (3) - month of the dosimeter's production;
On a display (4) - year of the dosimeter's production;
Audible alarm - On (enable).

"Alarm clock" indication mode – On (enable)
On a display (2), figure 1.2 – the symbol "AL" of the alarm clock mode;
On a display (4) – hours and minutes.

"Timer" indication mode – On (enable)
On a display (2), figure 1.2 – the symbol "TR" of the timer mode;
On a display (3) – seconds;
On a display (4) – hours and minutes.

"Stop-watch" indication mode – On (enable)
On a display (2), figure 1.2 – the symbol "ST" of the stop-watch mode and decimal parts of a second;
On a display (3) – seconds;
On a display (4) – hours and minutes.

"Clock-calendar" indication mode – On (enable)
On a display (2), figure 1.2 – the day of the week;
On a display (3) – seconds;
On a display (4) – hours and minutes.

2.4.2 DER indication mode

In the DER mode (figure 2.1) the following parameters are indicated on the LCD:

- DER (μSv/h, mSv/h, Sv/h);
- DER on the analogue scale in a logarithmic gauge (seven segments);
- current time in hours, minutes and seconds or 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 "**- - -**" are indicated on the LCD), coefficient of variation in percents.

If the measured DER value is over the upper limit of the DER indication range (6.50 Sv/h for the PM1604A and 13.0 Sv/h for the PM1604B), the LCD will show the overload symbol "**OL**" and intermittent audible signal will sound.

In the DER mode the collected statistics of DER measurement can be reset and the process of measurement can be reactivated by simultaneous pressing of the **SET+MODE** buttons.

2.4.3 DE indication mode

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

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

DE and DE accumulation time reset is possible in the set mode by simultaneous pressing of the **SET+MODE** buttons (figure 2.2).
In the mode of data transmission to PC it is possible to set an inhibition for DE reset using the buttons.

2.4.4 Set mode

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.

To enter the "set" mode press and hold for about 5 s the **SET** button and the parameter to be set will be flashing.
To chose the parameter press and release the **SET** button.
To change the set parameter:

- rapidly – press and hold the **MODE** button;
- for exact setting – press and release the **MODE** button.

The dosimeter will exit the "set" mode by pressing and holding the **SET** button or automatically in approximately 90 s.

2.4.5 Inputting the DER (DE) threshold levels into the memory

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

Enter the set mode (figures 2.2, 2.3).
Input successively the first and then the second threshold levels.
Exit the set mode.

In the mode of data transmission to PC it is possible to set an inhibition 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 intermittent (frequent intermittent) audible signal will sound.

When DER value decreases 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 s, the repeated audible signal will sound in approximately 4 min.

2.4.6 The dosimeter's number indication mode

In the **dosimeter's number** indication mode the following parameters are indicated on the LCD:

- the dosimeter's number on a display (2);
- the year (4) and the month (3) of production.

2.4.7 Mode of data transmission to PC

The dosimeter allows storing and transmitting to PC a history (hereinafter "history") of DE, DER accumulation, events of exceeding the preset DE and DER threshold values, event of DE reset trough IR communication channel using the buttons.

Selection of the events to be stored in the history, frequency of these recordings is performed under a special program. History data are inaccessible without IR adapter.

The dosimeter performs data transmission to PC under a special program "System of Data Collection and Processing for the PM1621/PM1603/PM1604 Devices". Dosimeter through the adapter of IR communication channel over the communications protocol compatible with IrDA interface.

System requirements to a computer:
A PC not lower than Pentium 200; 32Mb RAM, monitor resolution 800 x 600, printer and unit for operation with IrDA protocol for the exchange of information with the dosimeter are necessary for comfort program running.
The program runs under OS Windows 98/2000 control.

For using the dosimeter in the **mode of data transmission to PC** it is necessary to:

- read and follow the recommendations of the file Read_me.doc on the CD which is available with adapter of IR communication channel;
- read the help file Help.doc;
- connect the adapter of IR communication channel to a PC COM port (it is possible to use PC internal IR adapter);
- install the unit of IrDA communication in the system and switch on the IR connection in the mode of searching external IR connection devices (for W 98);
- install the program "System of Data Collection and Processing for the PM1621/PM1603/PM1604 Devices" from the CD, (run the program \DISK1\SETUP.EXE following the instructions of the file Help.doc);
- run the program PM16XX.EXE;
- read the help section of the program "System of Data Collection and Processing for the PM1621/PM1603/PM1604 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 adapter of IR channel;
- choose the mode of data transmission to PC using the MODE button (figure 2.1);
- press and release the SET button for PC link startup through IR channel;
- perform readout of the dosimeter's information, following the program's instructions.

Attention! The long stay in the mode of data transmission to PC (on/IR) decreases the battery service life.

2.4.8 “Alarm clock”, “timer”, “stop-watch”, “clock-calendar” modes

Press and release the MODE button to enter the “**alarm clock”** mode.
To set the time of the alarm clock turning on, enter the “set” mode by pressing and fixing the SET button and set the necessary time using the MODE and SET buttons, leave the “set” mode by pressing and fixing the SET button (Figure 2.3).
For switching on/off the function of the alarm clock turning on at the set time press and release the SET button in the alarm clock mode.

If the current time coincides with the time of the alarm clock turning on, the alarm will sound for about 20 seconds. Press any button to silence the alarm sound.

Press and release the MODE button to enter the **“timer”** mode (Figure 2.4). Press and release the SET button to start or to stop timer. When the timer is on, the alarm will sound for about 20 seconds. Press any button to silence the alarm sound.
Hours, minutes, seconds are set with the MODE and SET buttons while in the “set” mode. To enter the “set” mode press and fix the SET button.

Press and release the MODE button to enter the **“stop-watch”** mode (Figure 2.5). Press and release the SET button to start, to stop or to reset the stop-watch.

Press and release the MODE button to enter the **“clock-calendar”** mode.
Press and release the SET button to display the year and the month in the **“clock-calendar”** mode (Figure 2.1).
To set the current time and calendar, enter the “set” mode by pressing and fixing the SET button and set the selected parameter using the MODE and SET buttons (Figure 2.5).

The days of the week are named as follows: MO-Monday, TU – Tuesday, WE – Wednesday, TH – Thursday, FR – Friday, SA – Saturday, SU –Sunday.

2.4.9 Partial or critical battery discharge indication mode

The dosimeter controls battery discharge once in 10 minutes.
In case of the battery **partial discharge** (approximately 2.7 V) the LCD will indicate the flashing symbol "bat". ***The battery is to be replaced! (see 3.3).*** In case of the battery **critical discharge** (approximately 2.65 V) the dosimeter will turn into the DE indication mode, the symbol "bat" will become solid, the dosimeter will stop the measurements, LCD backlight and audible alarm will become locked.

The battery is to be replaced!

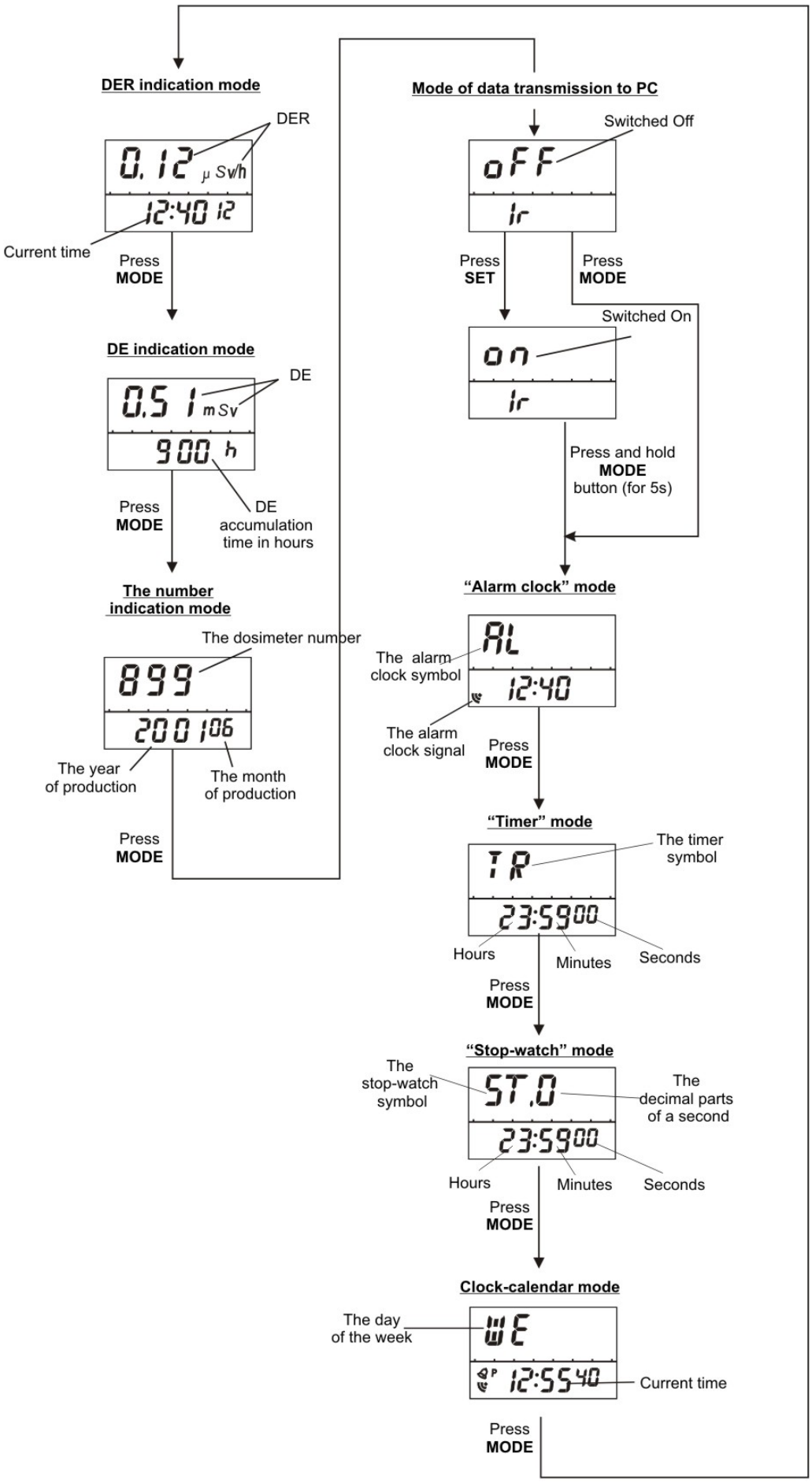

Figure 2.1 - Choice of operating mode (indication) of the dosimeter

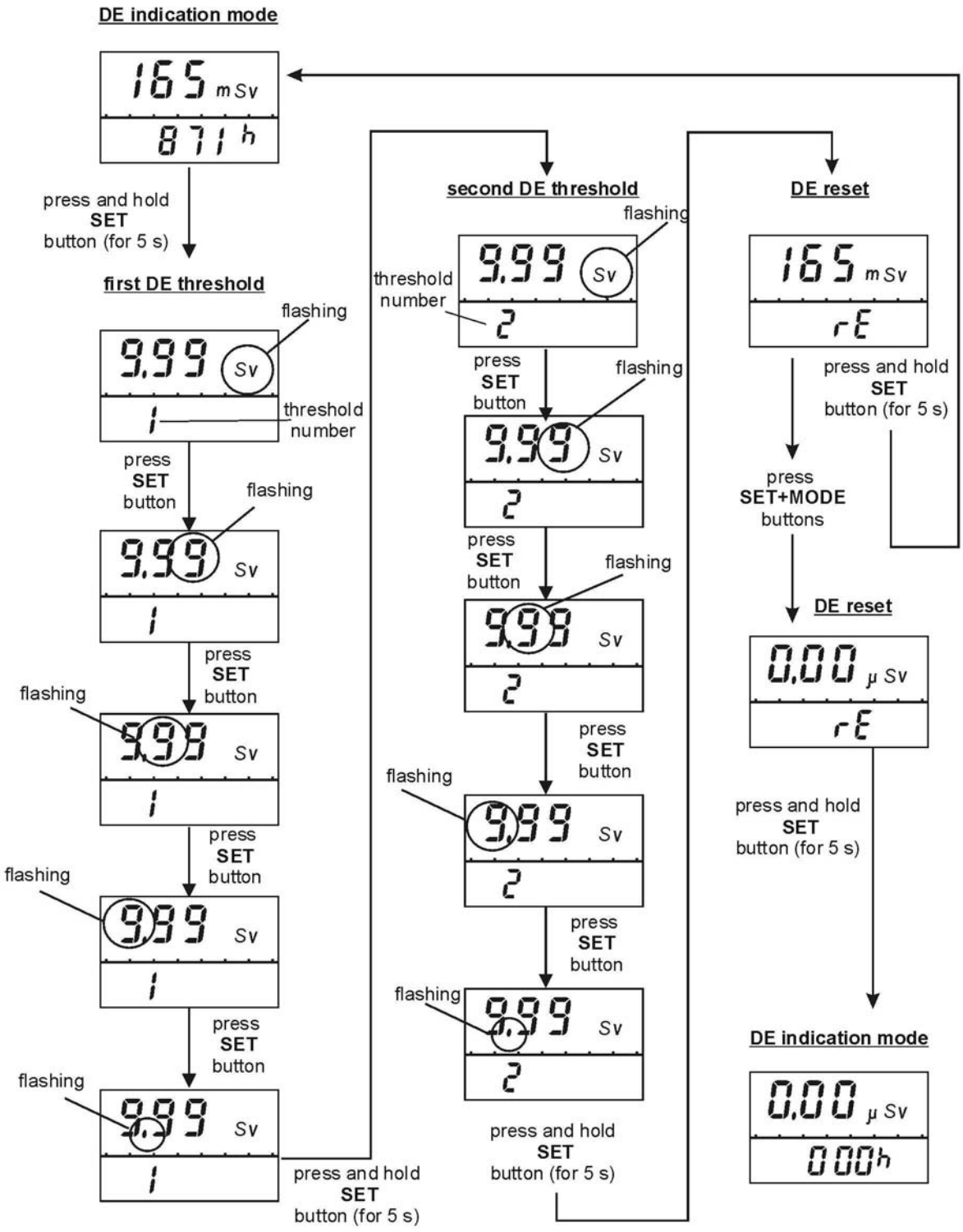

Figure 2.2 - Setting the DE threshold values

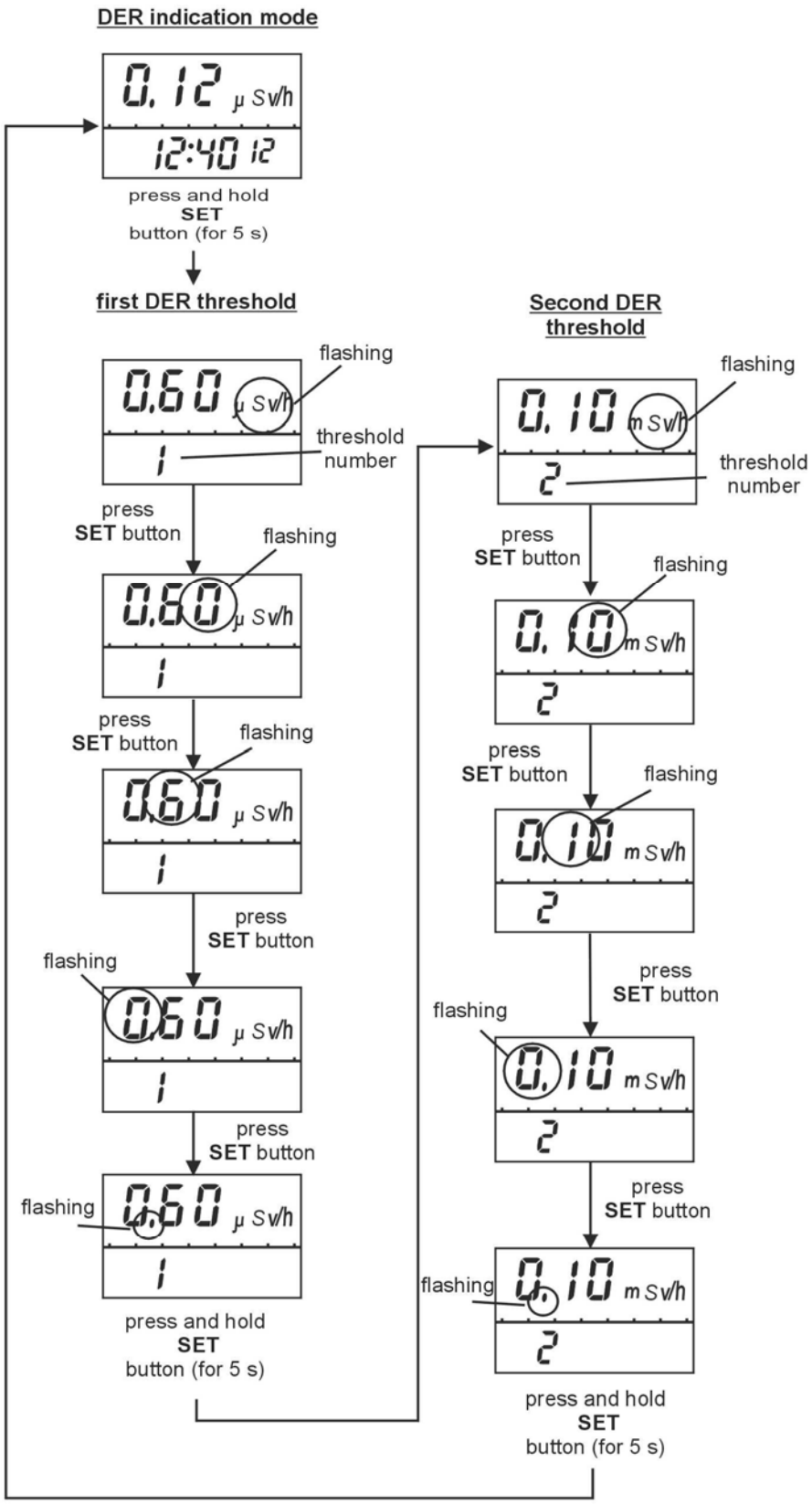

Figure 2.3 - Setting the DER threshold values

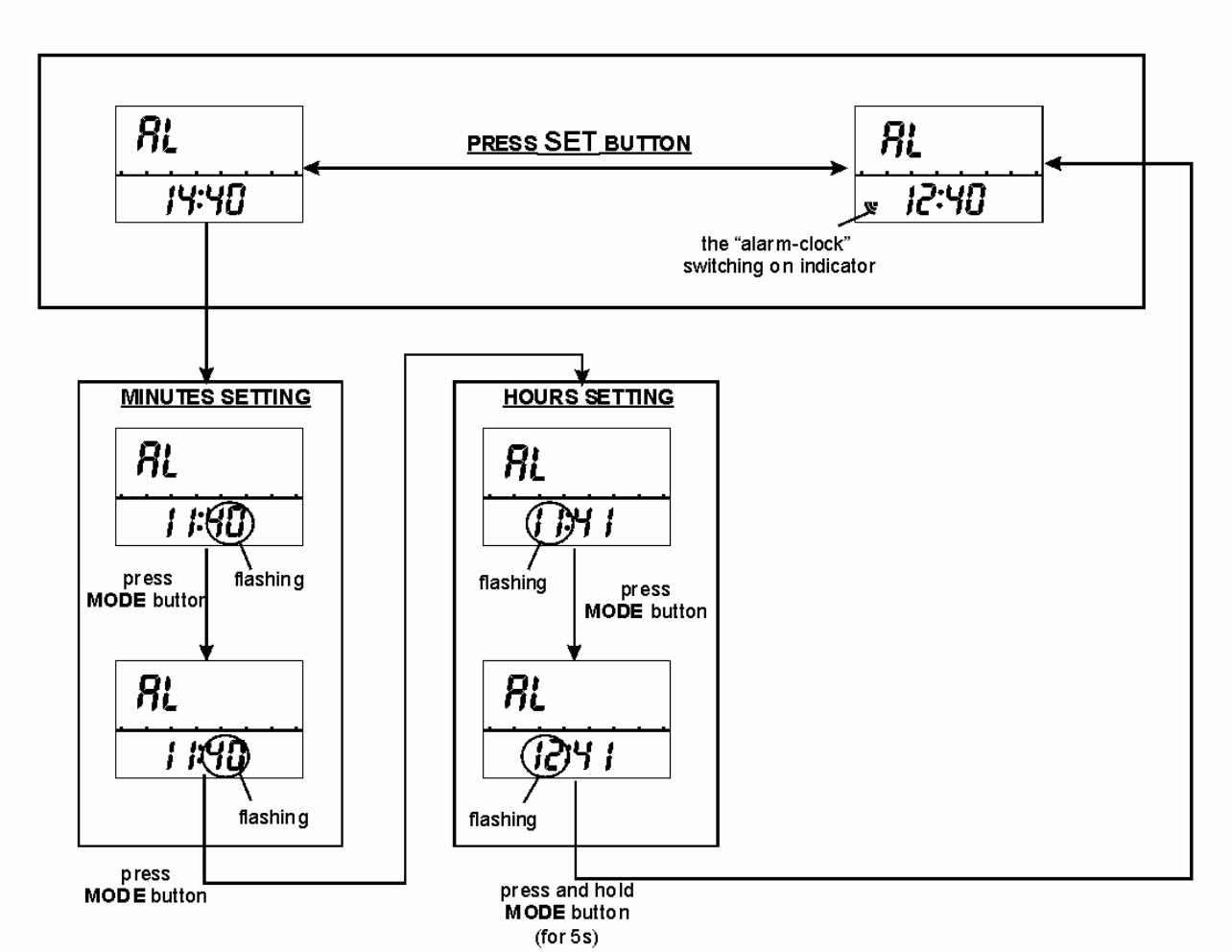

Figure 2.4 - Setting the parameters in “alarm-clock” mode.

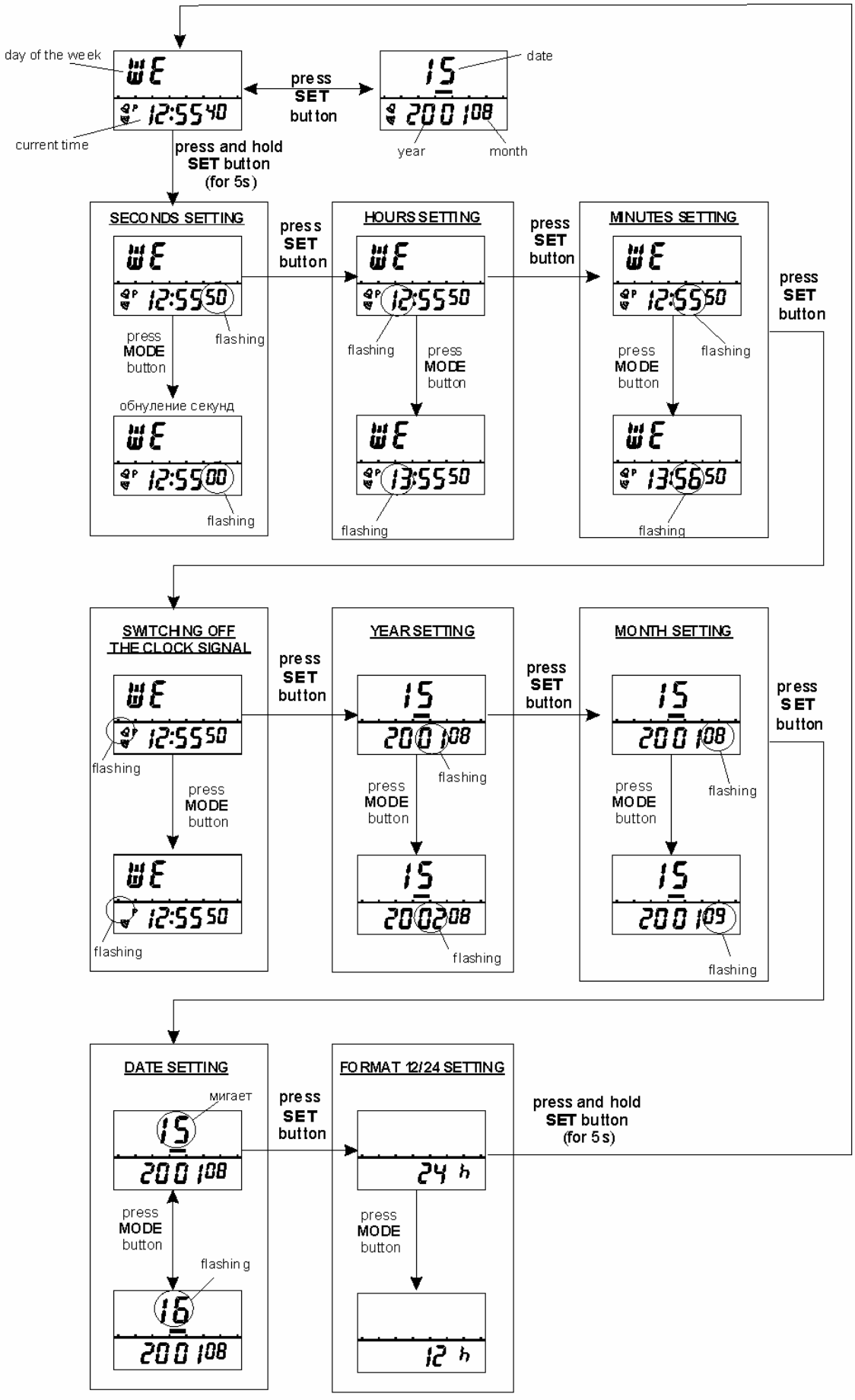

Figure 2.5 - Setting the parameters in “clock-calendar” mode.

3 MAINTENANCE

3.1 Maintenance involves preventive services, battery replacement and regular performance check (according to 2.4.2 - 2.4.6).

3.2 Preventive services include external examination, dusting and decontamination in the event of radioactive contamination.
For decontamination wipe the case of the dosimeter using a cloth wetted with ethanol (GOST 18300-87).

3.3 Battery replacement:

1) Unscrew four screws and remove the rear cover of the dosimeter;
2) Remove the battery;
3) Insert a new battery observing the polarity (“+” outward directed);
4) The LCD will display all segments and the dosimeter will enter the DER measurement mode. If the dosimeter doesn’t respond to the buttons, the LCD displays wrong symbols it is necessary to remove the battery and install it again in 5 minutes;
5) Fix the rear cover with the screws;

Attention! The back cover should be placed in such a way that buzzer center which is installed on the inner surface of cover coincides with spring contact which is located next to the “+” sign. (If it does not coincide the cover should be turned by 180°).

6) Set the current time and date. All previous measurements and parameters necessary for correct operation of the dosimeter are stored in its non-volatile memory.

NOTE - Insert a new battery before sending a dosimeter 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 in the proper way
3. The dosimeter does not respond to pressing a button, the LCD indicates incorrect symbols	Microprocessor error condition	Remove the battery and insert it again in 5 minutes
4. The LCD indicates Er1-Er7	Dosimeter failure	Send the dosimeter for repair to the manufacturer’s maintenance center
Note – If a defective battery is used the Er1 – Er7 message may appear. **A t t e n t i o n ! When the Er1 – Er7 message appears, press any button. When the error message appears for the second time (approximately in 15 minutes) the dosimeter must not be used**.		

5 STORAGE AND SHIPPING

5.1. Dosimeters in package may be shipped by any kinds of closed transport at the air temperature from -50 °C to +50 °.

5.2. Dosimeters in package should be arranged and fastened in the transport so that their stable position is ensured and shocks are avoided.

5.3. When carried by sea, dosimeters in package should be placed in hermetic plastic bags with silicagel.

5.4. When carried by air, dosimeters in package should be placed in hermetic compartments. DER threshold 1mSv/h should be set when dosimeters are carried by air.

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

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

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

Attention! When the dosimeter is stored for more than 6 months it is necessary to remove the battery.

6 WARRANTY

6.1. The manufacturer guaranties that the dosimeter 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 (placing the dosimeter in service).

6.3. The warranty period of storage is 6 month since the date of dosimeter acceptance by the officer of the manufacturer Quality Control Department.

6.4. Warranty and after-warranty repair is carried out by the manufacturer or the institutions that have the manufacturer's permission

6.5. Warranty does not cover the dosimeters:

- without the operating manual;
- in case of their unauthorized opening;
- with mechanical damages and if the requirements of exploitation and storage were not satisfied;
- after expiration of the warranty period stated in item 7.2.

6.6. The warranty period of use is prolonged for a period of warranty repair.
6.7. Warranty does not cover the battery. The battery replacement is not considered as the warranty repair.

ATTACHMENT A

VERIFICATION TECHNIQUE

A.1 Introduction

This verification technique (1118-2002) extends to gamma radiation personal compact dosimeters PM1604A (PM1604B), corresponds to the Methodical Instructions 1788 "Radiation-monitoring devices for measuring the exposure dose and exposure dose rate, absorbed dose and absorbed dose rate of photon radiation in air. Verification technique" and establishes the verification technique for dosimeters.
The verification should be carried out by local bodies of the metrological department of the State Standard Committee and by institutions authorized to carry out these works.
The verification of a dosimeter should be carried out when releasing for sale, when releasing from repair and during operation and storage with a time interval of 12 months.

A.2 Operations and measuring instruments

The operations that should be performed during the verification procedure and measuring instruments that should be used are listed in Table A.1.

Table A.1

Operations	Technique section No.	Names of reference and auxiliary measuring instruments and major performances
1	2	3
External examination	A.7.1	-
Testing:	A.7.2	-
Determination of metrological characteristics	A.7.3, A.7.4	Dosimetric verification assembly with source ^{137}Cs according to Methodical Instructions 2050-90. The maximum certified error of the assembly should be not higher than 5% at 0.95 confidence level.
-	A.5	Barometer with the least division of 1kPa. Measurement range from 60 to 120 kPa.
-	A.5	Thermometer with the least division of 0.1°C. Measurement range from 10 to 30°C.
-	A.5	Hygrometer with measurement range from 30 to 90 %
-	A.5	Stopwatch with measurement range from 1 to 600 s
-	A.5	Dosimeter DBG-06T. Intrinsic error is ±15% (Other dosimeters providing the required accuracy of measurements may be used).
-	A.7.3.1, A.7.3.2	Hydrophantom with dimensions 30x30x15 cm*
* A plane-parallel phantom made of PMMA with dimensions 30x30x15 cm may be used.		

A.3 Expertise requirements to officers carrying out the verification tests

Persons certified as State Verification Officers are allowed to carry out verification tests and/or to interpret the results obtained.

A.4 Safety requirements

The following safety requirements should be observed when verification tests are carried out by the officers:

- works involving the use of radioactive sources should be carried out in conformity with the requirements cited in "Major health rules for treating radioactive materials and other sources of ionizing radiation" and "Standards of radiation safety", as well as with the instructions for the accident prevention that are in force in the site where verification tests are carried out;
- the verification process should be considered as work under special conditions.

A.5 Verification conditions

The following conditions are required for carrying out verification tests:

- temperature of the environment, °C 20 ± 5;
- relative air humidity, % 60 ± 15;
- atmospheric pressure, kPa 101.3 ± 4;
- background gamma radiation, μSv/h not more than 0.20.

A.6 Preparation for verification tests

Verification officers should do the following preparatory work before the verification tests:

- study the Operating Manual of the dosimeter;
- prepare the dosimeter for operation according to the section 2.3 of the Operating Manual.

A.7 Verification procedure

A.7.1 During the external examination the dosimeter should be tested against the following requirements:

- the delivery kit of the tested dosimeter should be the same as described in the manual;
- the initial or last verification test should be recorded in the manual;
- the dosimeter should be marked with clear inscriptions;
- pollution and mechanical damages that may influence the work of the dosimeter should be eliminated.

If the above requirements are not satisfied, the dosimeter cannot be accepted for further verification.

A.7.2. During testing it is necessary:

- to check the operation of the dosimeter as described in the section 2.4 of the manual;
- to set the maximum individual dose equivalent rate $H_p(10)$ (DER) and individual dose equivalent $H_p(10)$ (DE) threshold values as described in the section 2.4.4 of the manual.

A.7.3. Determination of metrological data

A.7.3.1. To determine the intrinsic relative error of the DER measurements the following operations should be performed:

1) enter the DER mode using the MODE button;

2) fix the dosimeter on a phantom, the inscription “Side towards the body” facing the dosimeter. Place the dosimeter with a phantom on a dosimetric verification assembly with a ^{137}Cs gamma radiation source; the graduation direction should coincide with the direction of radiation flow and the longitudinal axis of radiation flow should pass through the geometric center of the detector, Figure A.1. Geometric center of the detector is marked with ”x” sign in the operating documentation;

3) calculate the average background value of dosimeter’s readings at the absence of gamma radiation source. For this in no less than 300 s after placing the dosimeter on a dosimetric verification assembly and at intervals of no less than 150 s take dosimeter’s readings and calculate the average DER background value H_{ϕ}, in mSv/h, by formula

$$\overline{\dot{H}}_{\phi} = \frac{1}{n}\sum_{i=1}^{n}\dot{H}_{\phi i} \qquad (1)$$

where n - is the number of measurements equal to 5;

$H_{\phi i}$ - is the dosimeter’s reading at i-measurement of DER background, in mSv/h.

Notes

1 The measured DER background values in the range of 0.001-1.0 mSv/h are indicated in μSv/h, so when calculating the average value of DER it is necessary to transfer μSv/h in mSv/h;

2 Conversion from kerma in the air K (in Grays) to the individual dose equivalent $H_p(10)$ (in Sieverts) for ^{137}Cs source when performing measurement on a plane-parallel tissue-equivalent phantom is made by formula Hp(10)=1,21 K.

4) create DER H_{oj} = 3.0 μSv/h at a point of the geometric center of the detector and irradiate the dosimeter; two segments should be indicated on the analogue scale;

5) In no less than 300 s after the beginning of irradiation and at intervals of no less than 60 s take the dosimeter’s readings and calculate the average value H_j, in mSv/h, by formula (2); during this the indicator of DER value on the analogue scale should be indicated one segment

$$\overline{\dot{H}}_{j} = \frac{1}{n}\sum_{i=1}^{n}\dot{H}_{ji} \qquad (2)$$

where n - is the number of measurements in every point equal to 5;

H_{ji} - is the dosimeter’s reading at i-measurement in the tested point of DER, in mSv/h;

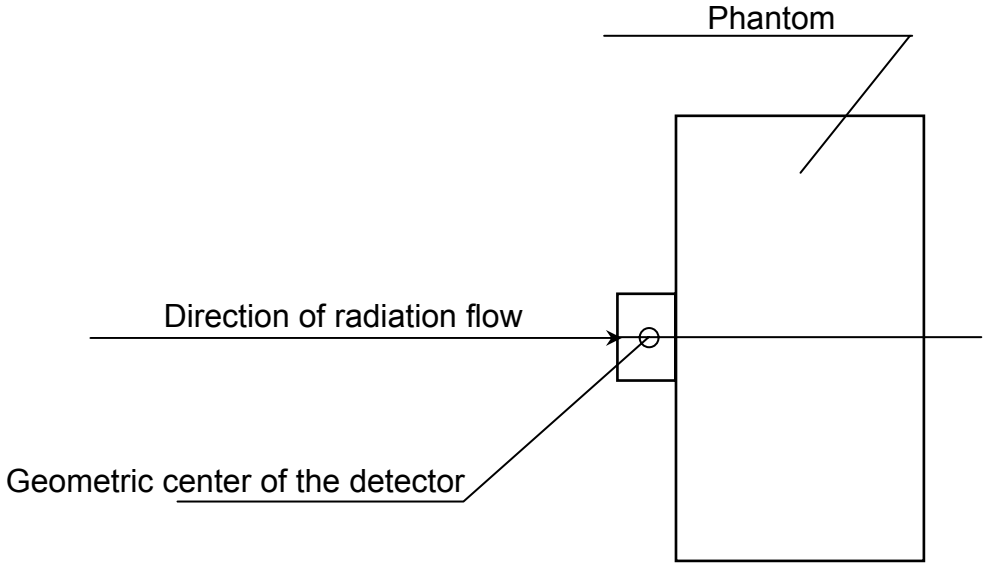

Figure A.1 – The method of mounting the dosimeter with a phantom on a dosimetric verification assembly

7) create DER equal to 0.08 mSv/h at a point of the detector geometric center;

8) irradiate the dosimeter;

9) in no less than 60 s after the beginning of irradiation and at intervals no less than 20 s take the dosimeter's readings and calculate the average value of H_j by formula (2); during this the indicator on the analogue scale should be indicated two segments;

10) repeat measurements for the points where the DER is equal to 8.0, 800 and 4000 mSv/h. Repeat the measurements for PM1604B dosimeter for the point where DER value is equal to 8000 mSv/h. During this the indicator of the analogue scale fourth segments should be indicated when DER is equal to 8.0 mSv/h, six segments should be indicated when DER is equal to 800 mSv/h and seven segments when DER value is more than 1000 mSv/h;

11) calculate the intrinsic relative error Q_j of DER measurement for each point in percents by formula

$$Qj = \left| \frac{\left(\dot{\overline{H}}_{J} - \dot{\overline{H}}_{\Phi}\right) - \dot{H}_{Oj}}{\dot{H}_{Oj}} \right| \times 100\% \qquad (3)$$

where H_{Oj} - is a calculated value of DER in the point of measurement, in mSv/h;

H_j - is the measured average value of DER in the point of measurement, in mSv/h;

H_Φ - is the measured average value of DER background in the point of measurement, in mSv/h.

12) calculate the confidential limits of the permissible intrinsic error δ of DER measurement, in %, for the confidence coefficient 0.95, by formula (4):

$$\delta = 1{,}1\sqrt{(Qo)^2 + (Qj)^2} \qquad (4)$$

where:

Qo- is an error of a standard dosimetric assembly (in %);

Qj- is the intrinsic relative error of DER measurement calculated by formula (3), in %.

13) Compare the confidential limits of the permissible intrinsic error δ calculated by formula (4), with an acceptable value of the permissible intrinsic error δ_{acc} calculated by formula (5)

$$\delta_{acc} = \pm(15 + K_1/H + K_2 H) \%, \qquad (5)$$

where H – is DER value, mSv/h;

K_1 – coefficient equal to 0.02 (mSv/h);

K_2 - coefficient equal to 0.003 $(mSv/h)^{-1}$ (for PM1604A dosimeter);

K_2 - coefficient equal to 0.002 $(mSv/h)^{-1}$ (for PM1603B dosimeter);

If $\delta > |\delta_{acc}|$ the dosimeter is rejected, if $\delta \le |\delta_{acc}|$ the dosimeter is considered to be good.

A.7.3.2. To determine the intrinsic relative error of the DE measurements the following operations should be performed:

1) set the maximum values of the DER and DE thresholds and enter the DE measurement mode. To reset the accumulated DE value;

2) perform item A.7.3.1, point 2 of the present technique;

3) read the initial DE value from the dosimeter;

4) create DER equal to 8.0 mSv/h from the ^{137}Cs gamma radiation source at a point of the geometric center of the detector and irradiate the dosimeters during the time period T equal to 30 min;

5) read the final DE value after the end of irradiation;

6) calculate the intrinsic relative error G_j of DE measurement, in %, by formula:

$$G_j = \left| \frac{\left(H_{kj} - H_{Hj}\right) - \dot{H}_{oj} \cdot T}{\dot{H}_{oj} \cdot T} \right| \times 100\% \qquad (6)$$

where H_{kj} - is a final DE value, in mSv;

$H_{нj}$ - is an initial DE value, in mSv;

$\dot{H}_{oj}$ - is a calculated value of DER in the point of measurement, in mSv/h;

T - is the time of irradiation in hours.

7) repeat measurements according to items (3-6) for the points where the DER value is equal to 80 mSv/h at T=30 min and for value 1500 mSv/h at T=20 min;

8) calculate the confidential limits of the permissible intrinsic error of the verified dosimeter for every point of measurement at the confidence coefficient 0.95, by formula (7):

$$\delta = 1.1\sqrt{(G_o)^2 + (G_j)^2} \qquad (7)$$

where G_o - is an error of a standard dosimetric assembly (in %);

G_j - is the relative error of DE measurement calculated by formula (6), in %.

Compare the confidential limits of the permissible intrinsic error δ calculated by formula (7) with the limits of an acceptable value of the permissible intrinsic error $\delta_{acc} = \pm 15$ %. If $\delta > |\delta_{acc}|$, the dosimeter is rejected, if $\delta \le |\delta_{acc}|$, the dosimeter is considered to be good.

A.8. Presentation of the verification results

A.8.1 The results of verification are entered in the recommended record.

A.8.2. With good results of the initial verification, a signature and a verification mark of an officer, as well as a stamp of the institution, at which the verification was carried out and the date of verification are put in section 9 (Acceptance Certificate) of the operating manual.

A.8.3. With good results of the regular verification or verification after the repair a verification certificate for the dosimeter of the set form is issued.

A.8.4. With bad results of the verification the dosimeters are not accepted for use. An unavailability report is issued for these dosimeters with indication of the reasons according to the set form. In this case verification mark of the officer is to be liquidated and the verification certificate is to be cancelled.

RECORD (recommended)No._____
of dosimeter 1604A(B) No. _____ verification results,
belonging to _____

The verification was carried out in normal conditions at T= _____; P= _____ GPa, relative air humidity _____ %, gamma background ____ μSv/h in accordance with Verification Technique presented in dosimeter "Operating Manual" on the dosimetric verification assembly _____ with reference source ^{137}Cs and also with auxilliary measuring instruments.

Auxilliary measuring instruments.

Name	Type	Serial number	Date of verification
Thermometer			
Aspiration psychrometer			
Aneroid-barometer			
Dosimeter			

DER measurement range for the PM1604A dosimeter is from 1 μSv/h up to 5.00 Sv/h and for the PM1604B dosimeter from 1 μSv/h up to 10.0 Sv/h

DE measurement range is from 1.0 μSv up to 9.9 Sv.
Maximum permissible intrinsic relative error of DER measurement:

$$\delta_{acc} = \pm(15 + K_1/H + K_2H)\ \%,$$ where H - DER value, mSv/h;

K_1 – coefficient 0.002 (mSv/h);
K_2 – coefficient equal to 0.003 $(mSv/h)^{-1}$ (for the PM1604A modification);
K_2 – coefficient equal to 0.002 $(mSv/h)^{-1}$ (for the PM1604B modification);
Maximum permissible intrinsic relative error of DE measurement in measurement range $\delta_{acc} = \pm$ 15 %.

1. The external examination _____

---

2. Testing and checking the operation of the dosimeter : _____

---

3. Determination of metrological data:

3.1. Determination of the intrinsic relative error of DER measurement.

Actual value H_{jo}, mSv/h	Source No R, sm	Dosimeter readings		Q_j %	δ %	δ_{acc} %
		H_{ji}, mSv/h	H_j, mSv/h			
0,003						
0.8						
8.0						
80.0						
800.0						
4000.0						
8000.0						

3.2. Determination of the intrinsic relative error of DE measurement.

Actual value H_{jo} , mSv/h	Source No R, sm	DE accum. time, T, min	Calculated DE value, H_{jo} , mSv	Dosimeter readings, mSv		δ, %	δ_{acc}, %
				initial H_{ij},	final H_{ej}		
8		30	4				
80		30	40				
1500		20	500				

Conclusions: _____

Certificate _____ date _____

State verification officer _____ _____
signature name

Date _____

ATTACHMENT B
DIAGRAM OF DOZIMETER ROTATION TO MESURE ANGULAR RESPONSE

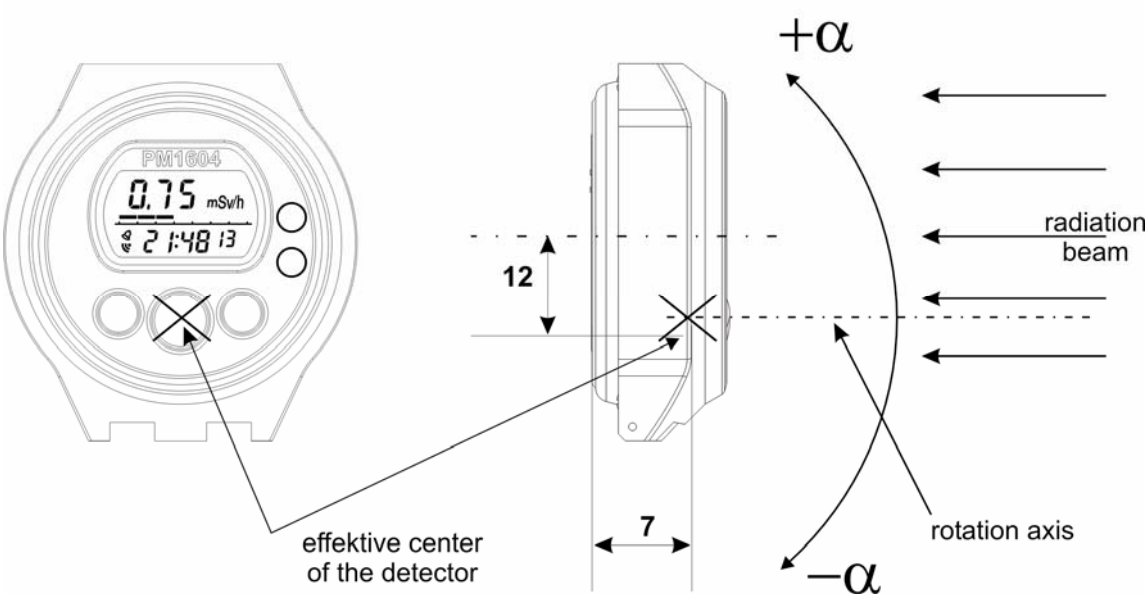

Figure B.1 Diagram of dosimeter rotation in horizontal plane

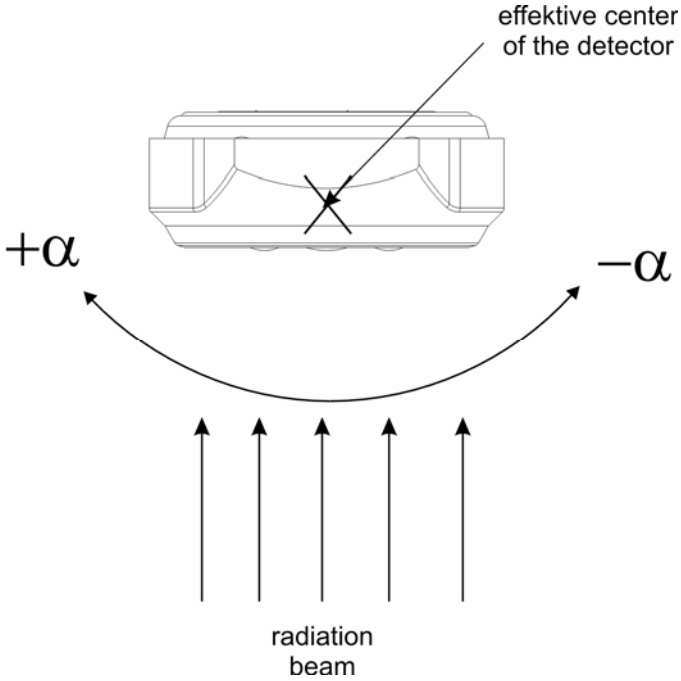

Figure B.2 Diagram of dosimeter rotation in vertical plane