МЕТОДИКА ОПРЕДЕЛЕНИЯ ДОЗОВЫХ НАГРУЗОК ПРИ ВЫХОДЕ РЕНТГЕНОВСКОГО ИСТОЧНИКА НА РАБОЧИЙ РЕЖИМ

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MEASUREMENT METHOD OF THE RADIATION BURDEN OF THE X-RAY SOURCE IN THE PROCESS OF STABILIZATION

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The article describes the method of determining the dose rates at the exit X-ray source on the operating mode. The possibility of using this technique to determine the dose rate pulsed source. Results of testing the methodology presented at the pulsed X-ray machine ATM-160-5 using thermoluminescent dosimeters DTL-02.

Nowadays one of the main tasks of the X-ray diagnostics researches is to find the methods that can be used to reduce the doses for the patients. In the operation cycle of detectors time stamp is needed to process and transmit signals. The excessive radiation burden is excluded when the pulsed X-ray source is synchronized with the detecting device. In the Department of Applied Physics of the National research Tomsk polytechnic university the X-ray visualization devices based on the pulsed X-ray generator RAP-160-5 were created [1].

The radiation burden measurements from a pulsed source have a number of difficulties. One of them is associated with the response rate of the dosimeters. This problem can be solved by using the storage type of the detectors, for example, the thermoluminescent detectors. These dosimeters can be used for the dose distribution and the integral dose measurements in the medical examination [2]. Another problem is associated with the excessive radiation burden to the patient at the time of the X-ray source in the process of stabilization.

The research objective is to develop the measurement method of the radiation burden of the X-ray source in the process of stabilization.

Materials and methods *Source of emission***.** The irradiation was produced by the pulsed X-ray generator RAP-160-5. The main parameters of the X-ray generator: the focal spot size is 1,2 ×1,2 mm; the anode current varies from 0,4 to 5 mA; the impulse frequency radiation varies from 60 to 700 Hz; the duration of one pulse is about 140 μs. The X-ray generator can be synchronized with the other devices [3].

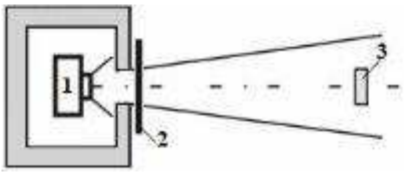

Fig. 1. The scheme of irradiation of the dosimeters at the X-ray generator RAP-160-5

Dosimetry equipment. In the experiment the solid thermoluminescent detectors DTL-02 for the staff personal dosimetry were used. These dosimeters comply with requirements of the task. Operating limits of the dose rates and absorbed doses correspond to the operation conditions [4].

Experimental setup. The experimental setup scheme is shown in the figure 1. Between the X-ray generator RAP-160-5 (1) and the thermoluminescent dosimeter DTL-02 (3) an aluminum filter (2) was installed (3,0 mm thick) to reduce the contribution of soft X-rays of the spectrum (figure 1). The distance between the X-ray source focus and the detector was 50 cm. The radiation was produced by the following parameters of the X-ray tube: the anode voltage was 100 kV, 70 kV, 40 kV; the anode current varied from 1,5 to 3,5 mA in increments of 1,0 mA

Measurement method of the radiation burden of the X-ray source in the process of stabilization. In the figure 2 the dependence of the dose rate on the pulsed X-ray tube elapsed time are shown. It was assumed that the dose rate rises linearly during the time of the X-ray tube in the process of stabilization.

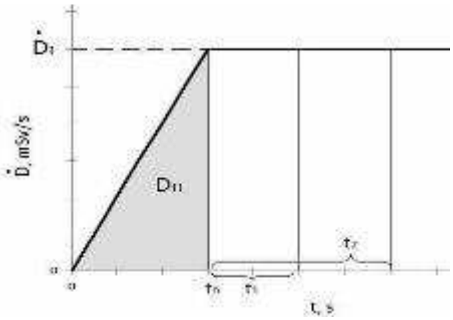

Fig.2. Plot of the dose rate depending on the pulsed X-ray tube elapsed time

Using the plot (2) two variants of irradiation were considered. In the first case total operating time is combined from the time of the pulsed X-ray tube in the process of stabilization (t_n) and the first time of the operating mode (t_1). In the second case total operating time is combined from the time of the pulsed X-ray tube in the process of stabilization (t_n) and the second time of the operating mode (t_2). The second time of the operating mode should be more than the first time of the operating mode. The figure 2 shows that the dose from the time of the pulsed X-ray tube in the process of stabilization can be calculated from the following system of equations:

$$\begin{cases} D_n + t_1 \cdot \dot{D}_r = D_1 \\ D_n + t_2 \cdot \dot{D}_r = D_2 \end{cases} \Rightarrow \dot{D}_r = \frac{D_2 - D_1}{t_2 - t_1} \Rightarrow D_n = D_1 - t_1 \cdot \dot{D}_r = D_2 - t_2 \cdot \dot{D}_r \qquad (1)$$

where, D_n – dose from the time of the pulsed X-ray tube in the process of stabilization; t_1, t_2 – times of the pulsed X-ray tube operating mode in the first and the second cases correspondingly, $\dot{D}_r$ – dose rate from the pulsed X-ray tube; D_1, D_2 – accumulated dose in the first and the second cases correspondingly.

Measurements of the dose of the X-ray source in the process of stabilization. According to the scheme in the figure 1 for the dose measurements of the pulsed X-ray source the thermoluminescent dosimeters DTL-02 were used. The measurements were produced by three different DTL-02 dosimeters at the equal X-ray tube operation mode.

The dose measurements were carried out by the method described previously. Since the dosimeter DTL-02 measurement accuracy is about 7,5 % the dose from the time of the pulsed X-ray tube in the process of stabilization should be commensurate with the total dose [4]. Consequently, the times of the pulsed X-ray tube operating mode in the first and the second cases were selected correspondingly. The time of the pulsed X-ray tube in the process of stabilization was selected depending on the X-ray tube parameters.

The method can be used for the determination of dose rate values and the values of the dose from the time of the pulsed X-ray tube in the process of stabilization. The dose rates from the pulsed X-ray tube and the doses from the time of the pulsed X-ray tube in the process of stabilization were calculated from the equation (1).

Results and discussions In the figure 3 the dose measurement results at the pulsed X-ray tube in the process of stabilization depend on the anode current of the pulsed X-ray source tube using the thermoluminescent dosimeters DTL-02 are shown. In the figure 4 the dose rate measurement results depend on the anode current of the pulsed X-ray source tube using the thermoluminescent dosimeters DTL-02 are shown. The dose and the dose rate measurement results for the different anode voltages are average over three different DTL-02 dosimeters

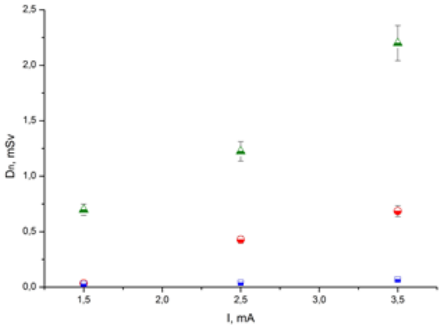

Fig. 3. The dose measurement results of the pulsed X-ray source: ▲ – the anode voltage – 100 kV; ● – the anode voltage – 70 kV; ■ – the anode voltage – 40 kV

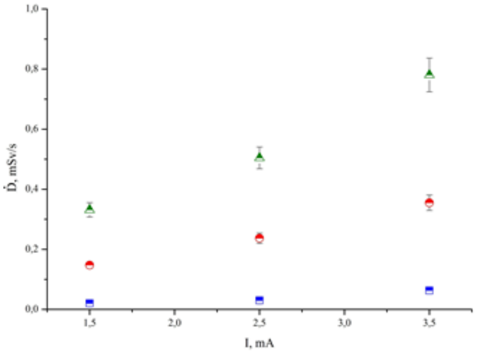

Fig. 4. The dose rate measurement results of the pulsed X-ray source: ▲ – the anode voltage – 100 kV; ● – the anode voltage – 70 kV; ■ – the anode voltage – 40 kV

According to the figure 3 the dose step junction can be explained by the following facts. The impulse oscillating frequency stepwise depends on the anode voltage of the X-ray tube. The values of the anode voltage and the anode current of the X-ray tube are inferential measurements. Since the X-ray tube is a pulsed source it specifies the integral value of the current [3].

Conclusion In the presented research the measurement method of the radiation burden of the X-ray source in the process of stabilization is given. *The obtained data show the advisability of using t*he proposed method for dose and the dose rate measurements of the pulsed X-ray generator RAP-160-5 under different X-ray tube parameters.

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