

Main Technical Characteristics Of Radiation Kilovoltmeter

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Abstract:

The paper considers the results obtained on a personal computer on the basis of the data obtained from the devices for monitoring the radiation and electrical characteristics of X-ray machines, calculating and displaying parameters such as anode voltage on the X-ray tube, exposure dose rate, exposure dose, exposure time, half attenuation layer, a graph of measurement over time and a graph of dose rate measurement from two detectors over time.

Keywords: personal computer, radiation control, X-ray machine, anode voltage, power, detector.

Introduction

The rapid progress in the development of equipment for radiation diagnostics requires more and more careful control of the main characteristics of the equipment. This progress is due to the rapid introduction of computer technology in the system of formation of medical imaging for radiodiagnosis. In the field of X-ray diagnostics, in addition to new digital devices, complexes for combined techniques have appeared: SPECT-CT, CT-MRI, etc., requiring a high radiation exposure to the patient and staff. In x-ray equipment, instead of three-phase generators, generators based on semiconductor circuits with power frequency conversion have begun to be used, which provide high accuracy in maintaining voltage and ripple at a level of 4%. At the same time, the genetically significant dose to the population from the impact of radiation diagnostics continues to increase (at least 1% per year), sometimes reaching a dangerous value. In X-ray diagnostic equipment, the radiation dose is the main parameter, and the dose is determined primarily by the voltage value on the X-ray tube. That is why the value of the anode voltage in the X-ray diagnostic apparatus requires constant and more and more careful monitoring. For such control, a special class of devices has been created, called radiation kilovoltmeters (sometimes they are called x-ray testers). In recent years, a new generation of radiation devices for measuring the output characteristics of X-ray diagnostic devices (RDA) has been established in the

world practice of medical X-ray technology. Their main distinguishing feature is the ability to connect a personal computer (PC) to the measuring device for the purpose of calculating, graphical visualization and storage (tabular logging) of the main RDA parameters. Examples of such devices are the Unfors Xi universal X-ray radiation dosimeter (Unfors Instruments, Sweden), the domestic X-ray tester devices for monitoring radiation and electrical characteristics in a new design with the ability to connect a PC to it, produced since 2013.

As already mentioned, the main reason for the appearance of such devices is the widespread introduction of a new generation of X-ray diagnostic equipment into medical practice: digital devices for radiography and fluoroscopy, and computed tomography. In the power devices of such devices, medium- and high-frequency generators are used, which provide an anode voltage with very low ripples and noise. Along with similar universal measuring devices that work with a PC, practically the same companies began to produce autonomous portable measuring devices for the rapid assessment of the technical condition of the RDA. Typical examples of such devices are the dosimeter "Mult-o-Meter" ("Unfors Instruments", Sweden), Russian X-ray tester devices for monitoring radiation and electrical characteristics in the basic design. To date, the SPC of Medical Radiology (GBUZ "SPTSMR DZM") has produced about 300 devices for monitoring radiation and electrical characteristics on consumer orders, which are successfully operated in many organizations in almost all regions of the Russian Federation. In 2013, there was a change in the Russian market of foreign models of devices for monitoring the characteristics of RDA (both universal and portable), certified and registered in the State Register of SI of the Russian Federation.

Instead of the Unfors Xi universal dosimeter, which was supplied to consumers in 2010-2012, the Swedish company RTI Electronics AB, from the beginning of 2013, began supplying (through a Russian distributor) a more advanced universal dosimeter for monitoring RDA parameters of the Piranha type in various modifications, providing, together with the PC, an extended technical expertise of various types of RDA (radiographic, fluoroscopic, mammographic, dental, CT).



Figure 1

From the same time on the domestic market, instead of the dosimeter "Mult-o-Meter", an autonomous, portable dosimeter appeared for the operational control of the characteristics of RDA of the "Cobia" type, manufactured by the same Swedish company. Since October 2013, the SPC for Medical Radiology has switched to the production of modified UKREH devices with Japanese X-ray detectors of the S8193 type, manufactured by Hamamatsu. The S8193 detector is a flat silicon photodiode with a GOS-type ceramic scintillator sputtered onto it. Its main advantage is the independence of the detector parameters from the influence of clinical environmental conditions (primarily humidity), hence the high stability of these parameters. This circumstance makes it possible to increase the stability of the characteristics of the devices for monitoring radiation and electrical characteristics, to expand the range of measuring electrical and dosimetric parameters of X-ray machines, and also to increase the accuracy of measurements.

The main technical characteristics of the portable autonomous device "Cobia" and the modified devices for monitoring radiation and electrical characteristics UKREH with Japanese detectors are given in Table. 1.

Table. 1.

Device type	Cobia	DMREC (2013)
Anode voltage	38...153 kV	40...150 kV
Dose	400 mcGy ... 1000 kGy	1,5 mcGy... 0,6 Gy
Dose rate	15 ... 100 μ Gy	0,15 ... 60 μ Gy/s
Exposure time	0,1 ms ... 2000s	10 ms...10s

The universal X-ray tester devices for monitoring radiation and electrical characteristics, interfaced with a PC (Fig. 2), also uses new Japanese detectors.

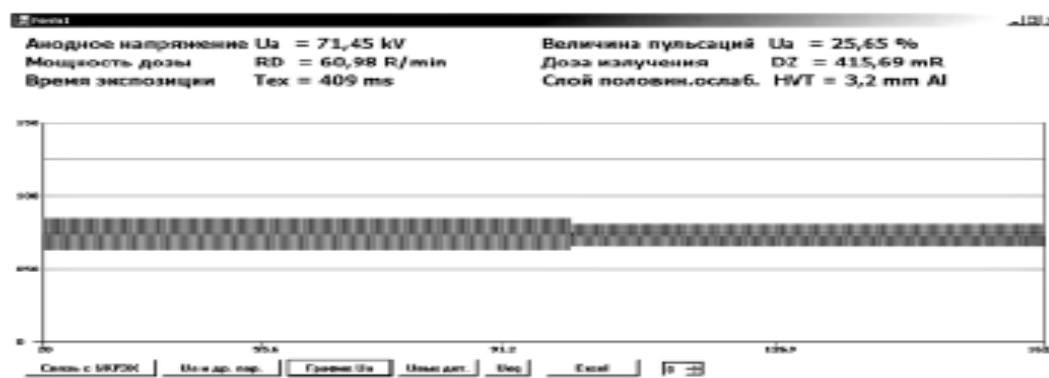


Figure 2

Connecting a PC to the devices for monitoring radiation and electrical characteristics makes it possible to visualize the characteristics measured by the devices for

monitoring radiation and electrical characteristics in graphical form (this primarily applies to the anode voltage, as well as to the output signals of detectors proportional to the radiation dose rate), implement various algorithms for processing and calculating the measured parameters, save them for subsequent registration and analysis at a relatively small increase in cost.

As a PC, a desktop PC, laptop or netbook with Microsoft Windows XP, Vista or Windows-7 operating systems containing an Excel spreadsheet processor and a .Net-Framework shell can be used.

To communicate with a PC, either an RS-232/RS-232 connecting cable (COM-1), or an RS-232/USB adapter, or a special Bluetooth module connected to the UKREX instead of an RS-232 cable is used.

To work with a PC using dotnet (.NET) technology in the C# language, a program was developed that provides communication between the devices for monitoring radiation and electrical characteristics and a PC, calculation, visualization and storage of measured characteristics with the possibility of exporting them to Excel.

The program was developed in the Visual Studio 2008 environment for the .Net Framework shell included in the PC OS. Based on the data received from the UKREH, the PC calculates and displays the following parameters:

- anode voltage on X-ray tube kVp (kVp RMS, kVpecv DC equivalent according to IEC 61676);
- exposure dose rate (radiation yield), R/min or mGy/s;
- exposure dose, mR or mGy;
- exposure time: 10...10000 ms;
- half attenuation layer HVL;
- graph of kVp measurement over time;
- graph of dose rate measurement from two detectors over time.

The working window of the program on the PC display at the end of the measurement process during one exposure has the form shown in fig. 13.

At the bottom of the window there is also a row of buttons controlled by the mouse. The "Ueq" button allows, using the array U_a , to calculate the so-called practical peak voltage (or equivalent DC voltage) in accordance with IEC 61676.

The Excel button connects to the Excel spreadsheet by creating an Excel instance and launching a new workbook based on a given template, where measurement data is exported, with each new measurement automatically written to a new table row. The entry is made in a numerical format, which enables automatic processing using formulas pre-written in the appropriate Excel cells.

Based on obtaining measurement results directly in the form of a dynamic table (Fig. 3) of changes in the electrical and radiation characteristics of an X-ray emitter, the proposed algorithm, unlike other similar devices, allows you to automatically process and obtain dependences of radiation dose linearity in real time without much routine

work on the amount of electricity, the radiation output from the anode voltage, the repeatability of the radiation dose at the same exposure mode settings, to evaluate the relative and absolute errors of the measured values, etc. This makes it possible (technical inspector) to quickly assess the technical condition of the power supply and emitter of the X-ray machine directly in the medical facility.

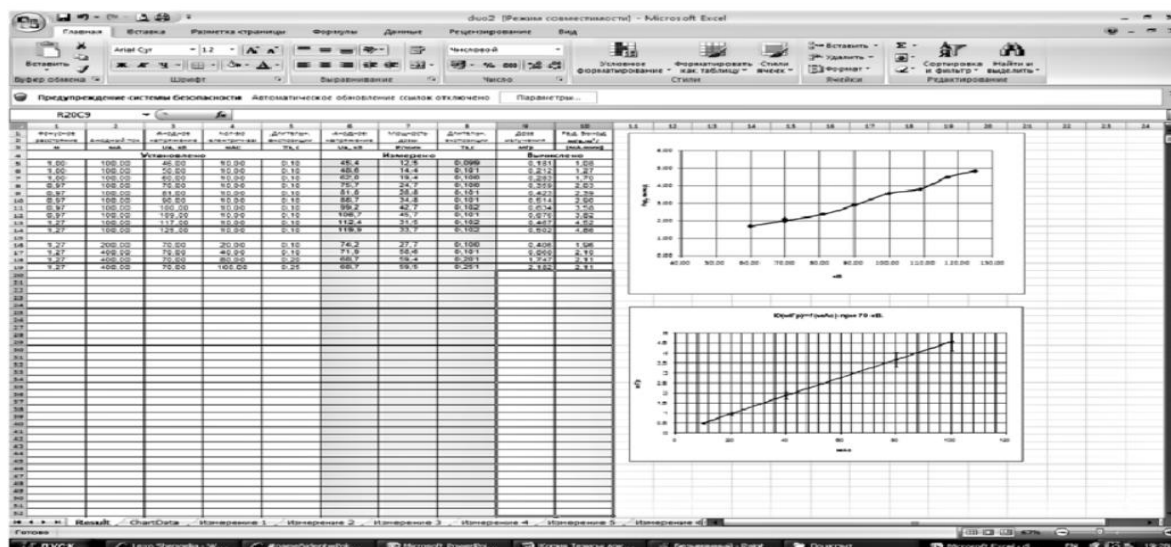


Figure -3

Operating experience of the new version of devices for monitoring radiation and electrical characteristics, combined with a PC, confirmed these advantages. The competitiveness of the upgraded version of the devices for monitoring radiation and electrical characteristics and its high efficiency in terms of maintenance and commissioning compared to foreign models of radiation kilovoltmeters are shown.

LIST OF USED LITERATURE

1. Г.И. Бердяков, Н.Н. Блинов Контроль характеристик рентгенодиагностических аппаратов в условиях эксплуатации. Медицинская техника. 2014;
2. Приборы рентгеновские. Методы измерения напряжения рентгеновской трубки ГОСТ 22091.4-86;
3. Л.Н. Тюленев, В.В. Шушерин, А.Ю. Кузнецов. Методы и средства измерений, испытаний и контроля. Екатеринбург 2005. С.84
4. А.Г. Дивин, С.В. Пономарев. Методы и средства измерений, испытаний и контроля. Тамбов. 2011. С.104.
5. М.А. Карягин Разработка радиационного киловольтметра для встроенной системы контроля рентгеновских диагностических аппаратов, Москва 2015.