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EVALUATION OF THE OPERATIONAL CHARACTERISTICS OF X-RAY EQUIPMENT

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ABSTRACT

The article is devoted to the quality control of the operational characteristics of modern general-purpose X-ray machines, which are a key element in the radiation protection of patients exposed to this type of medical exposure. The work was carried out by the research and testing radiological laboratory of the Center for the Development of Professional Qualifications of Medical Workers of the Ministry of Health of the Republic of Uzbekistan. For the study, 3 medical institutions in Tashkent were selected. Laboratory specialists tested the accuracy of the anode voltage setting, the reproducibility and constancy of the anode voltage setting on the X-ray tube, the total filtration, the radiation quality, the reproducibility and constancy of the output dose at a constant setting, the linearity and duration of exposure of the X-ray machines under study.

Key words: X-ray equipment, X-ray diagnostics, operational parameters, X-ray tube output dose, medical radiation doses.

INTRODUCTION

X-ray examinations are among the most common diagnostic methods, dominating among various types of radiation diagnostics in terms of information content and exposure. They are the main instrumental method for studying most diseases and mass preventive examinations of the population. With their help, 60-80% of clinical diagnoses are established, and for certain forms of diseases - up to 100% [4,7,9]. Due to X-ray procedures, covering the majority of the population of any region, more than 95% of the collective dose of medical radiation is currently generated [2,10].

Quality control of the characteristics of devices and instruments used in general radiographic diagnostics is a key element of radiation protection for patients exposed to this type of medical exposure [1,8].

Quality control refers to a system of organizational measures, technical means and technological procedures for quantifying, monitoring and maintaining the performance characteristics of diagnostic equipment at optimal levels.

The aim of the investigation – assessment of the performance characteristics of general purpose X-ray equipment.

Research materials and methods:

The work was carried out by the scientific research testing radiological laboratory of the Center for the Development of Professional Qualifications of Medical Workers, which is certified and accredited by the Uzbek Agency for Standardization, Metrology and Certification according to ISO 17025-2019 (The accreditation certificate is registered in the State Register of the National Accreditation System of the Republic of Uzbekistan dated August 30, 2021 ML.0392, valid until February 24, 2025).

For the study, 3 medical organizations in Tashkent were selected, where medical X-ray machines of the «Sonialvision» model manufactured by Shimadzu Corporation (Japan), manufactured in 2021, were installed. Tests were carried out on the basis of the following regulatory documents: Sanitary rules and regulations № 0194-2006 «Hygienic requirements for the design and operation of X-ray rooms, devices and the conduct of X-ray examinations», appendix 10 « List of operational parameters of medical X-ray equipment subject to control », ГОСТ 26140 «Аппараты рентгеновские медицинские», technical description and operating instructions from Shimadzu Corporation.

The tests were carried out using a multi-purpose X-ray dosimeter "UNFORS Xi" with a detector; measuring tape, electronic thermometer, test object for determining the geometry and axis of the radiation field. Equipment and measuring instruments have calibration or verification certificates valid until August 2025.

Results and discussion.

Control of operational parameters is control of the main characteristics of X-ray devices that affect the quality of the image and, accordingly, the accuracy of the obtained diagnostic information, as well as the level of radiation dose and personnel [3,5,6]. For the first time, requirements for this type of control in the Republic of Uzbekistan were introduced in 2006 in the Sanitary rules and regulations № 0194-06. Monitoring of the operational parameters of X-ray devices, technical tests and monitoring of the condition of diagnostic equipment is carried out when the devices are put into operation, as well as periodically during the

service life - once every 3 years. If X-ray machines are more than 10 years old, then monitoring of operational parameters is carried out annually. Regular prevention of deviations and identification of irregularities in the operation of equipment allows for timely reconfiguration or repair, which increases the service life and the quality of the research results provided by the devices.

Regulatory documents regulate the following parameters: constancy, reproducibility, accuracy of setting the anode voltage and exposure time, radiation output of the X-ray tube, control of beam geometry, control of the photo process.

Specialists of the Scientific Research Testing Radiological Laboratory tested the accuracy of the anode voltage setting, the reproducibility and constancy of the anode voltage setting on the X-ray tube, total filtration, radiation quality, reproducibility and constancy of the output dose with a constant setting, linearity and exposure duration of the studied X-ray devices, the results of which are presented in Tables 1-7.

Table 1

Results of testing the accuracy of setting the anode voltage on the X-ray devices under study

Installed on control panel			Measured values (kV)			Error (%)	Allowable error according to regulatory documents
kV	mAs	ms	1 dimension	2 dimension	average		
50	6,4	20	48,3	49	48,65	2,700	no more ±10%
60	16	40	60,5	60,5	60,5	-0,833	no more ±10%
72	22	45	73,7	73,7	73,7	-2,361	no more ±10%

Table 2

Results of testing the reproducibility and consistency of the anode voltage setting on the X-ray tube

Installed on control panel			Measured values (kV)			Error (%)	Allowable error according to regulatory documents
kV	mAs	ms	1 dimension	2 dimension	average		
50	6,4	20	48,3	49	48,65	-1,45	no more ±4%
60	16	40	60,5	60,5	132,2	0,00	no more ±4%
72	22	45	73,7	73,7	190,5	0,00	no more ±4%
72	10	20	73,7	73,15	73,425	0,75	no more ±4%
72	10	50	72,7	72,7	72,7	0,00	no more ±4%

Table 3

Total radiation filtration test results

Radiation Quality Test Results (kV)	X-ray emitter filtration (mm Al)	Additional filtering (mm Al)		Summary filtering (mm Al)	Equivalent total Filtration (mm Al) according to regulatory documents
		fixed	replaceable		
		collimator	replaceable filters		
72	1,1	2,1	-	3,2	no less 2,1

Table 4

Radiation Quality Test Results

X-ray tube voltage (kV)	Measured half attenuation layer (mm Al)	Minimum acceptable half attenuation layer (mm Al)
50	2,97	1,5
60	2,56	1,8
72	3,03	1,9

Table 5

Results of measuring the output dose, its reproducibility and constancy with a constant setting

Installed on control panel			Measured values (μGy)			Error (%)	Allowable error according to regulatory documents
kV	mAs	ms	1 dimension	2 dimension	average		
50	6,4	20	1,227	1,227	63,9	0,00	no more ±4%
60	16	40	289,9	290,9	132,2	-0,17	no more ±4%
72	22	45	586,6	581,6	190,5	-0,43	no more ±4%
72	10	20	691	690,2	690,6	0,12	no more ±4%

Table 6

Linearity Measurement Results

Installed on control panel		Measured values (μGy)			Deviation coefficient	Permissible deviation coefficient 0,1
kV	mAs	20ms	32ms	50ms		
72	10	265,6	260,8	257,1	0,006227	до 0,1

Table 7

Exposure duration test results

Installed on control panel			Measured values (μGy)			Error (%)	Allowable error according to regulatory documents
kV	mAs	ms	1 dimension	2 dimension	average		
50	6,4	20	20	20,1	20,05	-0,250	no more ±4%
60	16	40	40,1	40	40,05	-0,125	no more ±4%
72	22	45	45	45	45	0,000	no more ±4%
72	10	50	50	50	50	0,000	no more ±4%

The permissible error in the accuracy of setting the anode voltage on the X-ray machines under study, according to regulatory documents, is no more than ±10%. The error range is set from -2.361% to +2.700%, which is within normal limits. For reproducibility and consistency of the anode voltage setting on the X-ray tube of the X-ray machines under study, an error range is established from -1.45% to +0.75%, which is within the normal range according to regulatory documents (no more than ±4%). As a result of the tests, a total filtration value of 3.2 was obtained, corresponding to the standard (at least 2.1). The results of the measured half-attenuation layer at various voltages on the X-ray tube were normal. The output dose reproducibility error was in the range from -0.43% to +0.12%, which corresponds to the norm (no more than ±4%). The linearity deviation coefficient was 0.006227 with a norm of up to 0.1. The error of exposure duration is from -0.250% to 0%, the norm is no more than ±4%.

Collimation and indication of the X-ray beam size meets technical requirements. The focus-skin distance of the patient is from 47 cm to 110 cm. X-ray machines for radiography must be designed in such a way that it is possible to use a focus-skin distance of at least 45 cm.

Protection from unused radiation in the medical center X-ray rooms under study is provided by the ability for the operator to control the device from a protected operator room with a lead-lined door and glass.

Conclusions. Radiation doses to patients during X-ray examinations in Uzbekistan and throughout the world tend to increase. Most modern highly informative x-ray diagnostic methods fall into the category of “low”, and in children “moderate” radiation risk.

The values of medical and professional radiation doses during radiographic diagnostics largely depend on the quality of the technical operational characteristics of X-ray devices.

The studied stationary X-ray diagnostic devices of the “Sonialvision” model (Shimadzu Corporation, Japan), manufactured in 2021, comply with the requirements of the Sanitary rules and regulations of the Republic of Uzbekistan № 0194-06 “Hygienic requirements for the design and operation of X-ray rooms, devices and the conduct of X-ray examinations”.

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