QUALITY CONTROL FOR CONVENTIONAL X-RAY MACHINES

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Abstract

Introduction: This study will be conducted to quality control assessment of conventional radiology X-ray devices. The importance of radiology to confirm diagnoses and management plan became in priorities in diagnosis nowaday, as well as it is evident. Also, the whole medical field seek towards the development and control of equipment of X-ray

Marital and method : We will use standard quality control assessment tests that will be performed in this study, which include voltage accuracy as the first test, and reproducibility, then degree of exposure time, also we will use standard of tube output reproducibility, linearity, filtration,

and beam alignment will be performed and evaluated. All of theses assessment will be performed by using multi-purpose detector.

Result: By using the tools for calibration and Ray safe for measurement phantom measurement (HVL filter Exposure parameter :(Kv- mAs -HVL- image quality -Sensor) after take all measurement collected and analysis dates Excel sheet Compare radiation dose with national diagnostic reference level (AAPM74)

Conclusion: The primary objective of a quality assurance program in the radiology department is to ensure prompt and accurate diagnosis with minimal potential harm to patients and staff Assessment and Optimization of measurement for calculate dose checking the value of exposure to the X-ray machine .

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Introduction:

X-Rays and early radiography by Rontgen (1895–1928) For his discovery of X-Rays in 1895, Wilhelm Rontgen was awarded the Nobel Prize in 1901[1]. His reports included the first human radiograph of his wife, Anna Bertha's, hand. Other early radiographs emerging from a penchant for radiographing family and friends [2] are better, as are later radiographs of his buddy Albert von Kolliker's hand. Rontgen was a firm believer in open science and did not patent his discoveries, which he believed should be publicly available. Similarly, he gave his Nobel Prize money to science and later turned down a nobility offer. He was invited to join the Rontgen Society in the United Kingdom, which was the first medical X-Ray organization, but he rejected. Within a year following Rontgen's article, X-Rays were being used for diagnosis and therapy all around the world. While there were substantial benefits, there were also major risks to operators and patients. Intuitive protection measures began to be debated, albeit it took a long time for professional bodies to consider them, and much longer for them to become legally binding. This pattern is common; innovation and development come before formal norms and the law, and individuals with responsibility in these areas must be aware of this. In the year following Rontgen's discovery, approximately 1,100 publications on X-Rays were published due to the tremendous degree of curiosity in his invention.

Skin burns, dermatitis, skin malignancies, hair loss, and eye impairment were among the side effects recorded in the decades afterward [2]. Wolfram Conrad Fuchs of Chicago, who suggested keeping exposures as brief as possible and situating the x-ray tube at least 30 cm from the body, was one of the first attempts to offer safety guidance, mostly but not exclusively for employees. Filtration of the x-ray beam and collimation were suggested by others. Protective tube housings, leaded glass eyewear, collimated beams, and pulsed fluoroscopy were all advocated by Boston dentist William Rollins. The German Rontgen Society (Deutsche Rontgen-Gesellschaft) and others took notice of the proposals made during this time period and followed up on them. In 1913, the former published a one-page danger notice.

Further comment on the governance and ethics of positions taken by Rontgen is not relevant here because he resigned early from engagement with the medical development of his discoveries. The radiograph of his wife's hand (rather than his own) and his early unrestrained passion for hand radiography, however, lead to some suspicion. Such radiographs would obviously be inappropriate under today's radiation safety requirements. However, there was little, if any, understanding of the risk(s) that may be associated at the time. It's also possible that Rontgen's purpose was a desire to share the spotlight (which he didn't like for) with his wife, to whom he was devoted. There was also the prospect of a societal advantage in convincing people of the new discovery's usefulness. Rontgen's generosity in not patenting or restricting access to his invention, as well as in disbursing his Nobel Prize funds, was exceptional, and it is clear that he possessed a number of admirable traits [5-9].

History

X-rays were formerly thought to be a sort of unexplained radiation emitted by experimental discharge tubes before its discovery in 1895. Scientists studying cathode rays produced by such tubes, which are intense electron beams originally identified in 1869, noticed them. Many of the early Crookes tubes (developed around 1875) probably emitted X-rays, as evidenced by the effects noted by early researchers, as recounted below. Crookes tubes generated free electrons by ionising the tube's remaining air with a high DC voltage ranging from a few kilovolts to 100 kV. The electrons arriving from the cathode were accelerated to such a high velocity that they formed X-rays when they hit the anode or the tube's glass wall. [1].

William Morgan was the first researcher to be suspected of accidentally producing X-rays. He submitted a report to the Royal Society of London in 1785 explaining the effects of running electrical currents through a partly evacuated glass tube to produce an X-ray glow. [5][6] Humphry Davy and his assistant Michael Faraday expanded on this work.

Fernando Sanford, a physics professor at Stanford University, unintentionally produced and identified X-rays while developing his "electric photography." He had studied in the Hermann Helmholtz laboratory in Berlin from 1886 to 1888, where he became familiar with the cathode rays formed in vacuum tubes when a voltage was placed across different electrodes, as Heinrich Hertz and Philipp Lenard had previously explored. His letter to The Physical Review on January 6, 1893 (describing his finding as "electric photography") was duly published, and the San Francisco Examiner published a storey headlined Without Lens or Light, Photographs Taken With Plate and Object in Darkness. [9].

Philipp Lenard began experimenting in 1888 to investigate if cathode rays might escape the Crookes tube and into the air. He designed a Crookes tube with a thin aluminium "window" at the end facing the cathode so that the cathode rays would impact it (later called a "Lenard tube"). Something came through, exposing photographic plates and causing fluorescence, he discovered. He tested the beams' penetrating capability across various materials. At least some of these "Lenard rays" may have been X-rays, according to certain theories. [8].

Ivan Puluj, a lecturer in experimental physics at the Prague Polytechnic who had been building several types of gas-filled tubes to examine their characteristics since 1877, wrote a paper in 1889 on how sealed photographic plates got black when exposed to the tubes' emanations [5-7].

Hermann von Helmholtz developed X-ray mathematical equations. Before Rontgen's discovery and presentation, he proposed a dispersion hypothesis. He used the electromagnetic theory of light as his foundation. He did not, however, experiment with genuine X-rays.

Nikola Tesla began exploring this invisible, radiant energy in 1894 after noticing damaged film in his lab that appeared to be related with Crookes tube studies. Following Rontgen's discovery of the X-ray, Tesla began creating his own X-ray images with high voltages and tubes of his own design, as well as Crookes tubes.[2-7]

X-RAY MACHINE

X-RAY PRODUCTION

When electrons in motion collide with matter, X-rays are produced. Electrons interact with a target in an x-ray tube, and some of their kinetic energy is transformed into x rays or electromagnetic energy. Figure 1 shows a simple electrical x-ray tube system that depicts the fundamental method of producing x-rays with a radiographic tube. The x-ray machine creates a potential gap of 20-150kV between the anode and cathode of the x-ray tube [7]. A separate low voltage circuit generates current through a filament on the cathode side. The filament heats up and expels electrons due to the thermionic emission effect, which is caused by the current in the filament. An electron is produced by the large potential difference between the anode and the cathode. Tube voltage refers to the mobility of electrons between anode and cathode, whereas filament voltage refers to the energy of electrons in the cathode filament.

The two methods of converting energetic electrons to x-rays at the anode side are the Bremsstrahlung process and characteristic x-ray generation. X-rays escape from the tubes in both directions, but are limited by lead boxes and collimators to the proper beam size, where they interact with the subject and the sensor to produce a realistic image.

X-ray generator

A device that generates X-rays is known as an X-ray generator. It is frequently utilised in a range of applications, including medicine, X-ray fluorescence, electronic assembly inspection, and material thickness measuring in manufacturing operations, when combined with an X-ray detector. X-ray generators are used in medical applications by radiographers to get x-ray pictures of the interior structures (e.g., bones) of live creatures, as well as in sterilizing. [8]

To create X-rays, an X-ray generator usually includes an X-ray tube. Radioisotopes might perhaps be utilised to create X-rays.

The cathode, which guides a stream of electrons into a vacuum, and the anode, which gathers the electrons and is composed of tungsten to expel the heat created by the impact, make up an X-ray tube. When electrons clash with a target, only approximately 1% of the energy is released as X-rays, while the other 99 percent is released as heat. The target is commonly built of tungsten due to the tremendous energy of the electrons that approach relativistic speeds, even though other materials can be utilised in XRF applications.

An X-ray generator must also have a cooling system to keep the anode cold; many X-ray generators employ recirculating water or oil systems[9].

Bremsstrahlung process

The energy expended by an electron is determined by the electron path's direct contact with the nucleus, and hence by the frequency of the corresponding x-ray. The electrons were steered towards the target by creating a variety of radiography energies at various wavelengths through nuclei. The greatest potential x-ray energy is produced when an electron enters a nuclear reactor and releases all of its kinetic energy as an x ray. The energy spectrum for brake radiation is shown in Figure 2 [10]. The entire amount of energy given up by an electron is determined by the distance between the electron route and the nucleus, which determines the x-ray intensity. The nucleus produces a spectrum of x-ray energy when electrons travel at different rates across the target surface. Because the distance between the target nucleus and the nucleus width is quite large, low-energy x-rays are emitted rather than high-energy x-rays. This only happens when electrons go through the nucleus. The greatest possible x-ray power is emitted when an electron comes into direct touch with the nucleus and gives up all of its energy. Figure 2 depicts a bremsstrahlung energy spectrum. The energy released by bremsstrahlung x-rays on an unfiltered spectrum ranges from 0 to a

peak value computed by the engine's KV peak setting. To improve bremsstrahlung x-ray efficiency, it is preferable to employ a target material with a high atomic number and hence a nucleus with a significantly higher energy; this strategy results in more efficient electrostatic diversion of the streaming electron beams. Because tungsten has a high melting point and atomic number, it is commonly employed as a target[11].
The unmediated component of the x-ray spectrum created by bremsstrahlung label is represented by the dotted line in fig.2. The whole spectrum of x-rays is depicted in clear line format after escaping from the x-ray tube. Vertical straight lines depict the beams released by the x-ray tube. Bremsstrahlung and signature radiation are both included in the broad spectrum of pollutants. [12]

COMPONENTSOF X-RAY TUBE

The x-ray tube's main components are the anode, cathode, stator, rotor, and tank housing [13]. The surface of the tube, as well as the components inside it, is referred to as the tubing wrapping. When an x-ray tube cracks, it's usually only a matter of patching it together. The tube enclosure is removed, and oil is poured into the area between the shell and the casing to assist cool the tube and provide electrical shielding..

The basic components of an x-ray tube are:

a. To survive the extreme heat generated at the anode, a sealed glass tube envelope is built of glass or metal-ceramic with a high melting point. To avoid oxidation of the electrode materials, to allow rapid transit of the electrical current without ionisation of the gas within the tube, and to provide galvanic isolation between the electrodes, a vacuum distillation environment for the tube elements is required.
b. A source of electrons i.e. heated tungsten filament (cathode).
c. A metal target (anode). [14]

DESIGN CONSIDARATIONS FOR EQUIPMENT

To provide a crisp image, the focal point size is kept as tiny as feasible. The size of the focus point is a crucial factor in image quality. To generate an x-ray image with the least amount of blur, a tiny focus spot size is employed. Small focus spots concentrate heat and put a strain on the focal spot region [15]

TUBE HOUSING AND COLLIMATOR

The tube housing contains an opening that allows a beneficial X-Ray beam to emerge while simultaneously shielding it from harmful radiation. Leakage radiation must adhere to strict guidelines. Oil is used in the tube housing for electrical insulation and heat dissipation. To customise the size and form of the X-Ray, a useful beam is directed at the patient using an adjustable collimator.

CONTROL CONSOLE

Voltage (kVp), current (mA), and time are the three basic controls on the control console (s). The quality of the X-Ray is controlled by voltage, while the amount is controlled by current and time. The layout and functionalities of the control console are determined by the system and functions used. [16]

Cathode tube

The electrons in the Coolidge tube are created by the thermionic action of a tungsten filament heated by an electric current. The tube's cathode is the filament. Between the cathode and the anode is a high voltage potential, which accelerates the electrons before they hit the anode
End-window tubes and side-window tubes are the two types of tubes. End window tubes often feature a "transmission target" that is narrow enough to let X-rays flow through (X-rays are emitted in the same direction as the electrons are moving.)[17]
An electrostatic lens is employed to concentrate the beam into a very small region on the anode, which makes side-window tubes unique. The anode has been built specifically to remove the heat and damage caused by this extremely focussed assault of electrons.[18]

Anode tube

A stationary anode's focal spot (the area where the beam of electrons from the cathode strikes) generates a significant amount of heat [19,24]
During an exposure, the focus point temperature may reach 2,500 °C (4,530 °F), and the anode assembly can reach 1,000 °C (1,830 °F) after a series of long exposures. Anodes with a tungsten-rhenium target on a molybdenum core and graphite backing are common.[24-27]

Applications in various fields

1. The use of x-rays in clinical medicine was extremely crucial. X-ray images take use of the fact that higher-quality bones and teeth are less apparent on x-rays than other sections of the body [29].
2. Computerized axial tomography, or CAT scans, is a relatively recent way of using x-rays in the area of pharmaceuticals [29]
3. Moseley discovered that the intensity of a natural element's hallmark x rays may be used to detect it. This fact allows for a useful

approach of baseline analysis. When x rays of sufficient strength are used to impact a sample of unknown origin, the electrodes of the atoms of diverse sample components are disturbed, and the x rays are typical of such atoms.

4. The X-rays can be utilised for sales in a variety of other industries. Entire Xray images/engine components, for example, may be designed to identify flaws in a practical way [30]. A round ring of magnets protects the element in this circular orientation.[31-32]
5. X-ray lithography, which is utilised in the electronics industry for high-performance integrated circuits, is one of the most important industrial uses of synchrotron radiation, The shielding by a photographic resistant and blinding light of a mask-like stencil of the wafer on the top determines the circuitry's particular. [33-34]. The circuits on a wafer may be greatly reduced when x rays are utilised instead of light, and a specific size wafer can be used to produce much smaller electronic equipment, such as computers.[35]

Effects of radiation exposure on human body

Radiation has two kinds of health effects: acute perturbation and delayed perturbation. Acute disruption is an unavoidable impact that occurs when exposure exceeds a particular threshold, On the other hand, the danger of cancer from low-dose radiation exposure (less than 100 mSv) has yet to be properly established.[37]

Quality control

Medical imaging device quality control (QC) processes are mostly undertaken by certified businesses that are overseen by the National Radiation Protection Department (NRPD). In addition, QC checks on traditional radiological instruments are done every two years [36]. In 2003, the Atomic Energy Organization of Iran (AEOI) reported that 18,867,000 x-ray exams were performed on 12,963,000 patients [38].

[39]. In Chahar Mahal Bakhtiari province, seven radiological instruments were investigated for QC influence on patient dosage. They discovered that quality control can minimise patient dosage by at least 30%. [9] Furthermore, in a study of 44 devices in Golestan Province, Iran, [40] et al. discovered that exposure time accuracy was out of the normal range in 43.2 percent of radiological equipment [10]. Furthermore, [41] et al. investigated the effect of QC on 10 radiological equipment in Tehran province, finding that completing QC testing on these devices reduced patient dosage in 65 percent of cases. [10].

Because medical facilities in Cameroon have been unable to create any quality control programme, quality control (QC) testing on medical imaging devices are solely undertaken by the National Agency for Radiation Protection[42-43]

[44] saied that According to the ALARA principle, the average goal in diagnostic radiology is to give high-quality diagnostic images while limiting patient and worker doses to a minimum. An effective quality assurance (QA) procedure should be in place to maximise diagnostic radiology practice .

[45] suggested that The link between the radiation dosage provided to a patient and picture quality in X-ray diagnostic radiology provides a clear grasp of the relationship in optimising medical diagnostic radiology. Because a certain quantity of radiation must be supplied to patients, it should be kept as low as possible

[46] reported that, At the Iranian province of Khuzestan, quality control (QC) assessments of traditional radiology instruments were carried out in commonly frequented radiology centres. In addition, Based on the procedure described in Report No. 77 by the Institute of Physics and Engineering in Medicine, fifteen conventional radiology instruments were tested (IPEM).

[47] found There is a significant concentration in the categories of conventional and portable X-ray equipment, which account for 72 percent and 84 percent of the total number of equipment's, respectively. Half-value layer (HVL),

[48] showed The ALARA concept states that the major goal of diagnostic radiology is to give high-quality diagnostic images while limiting patient and worker doses to a minimum. Important diagnostic radiology performance tests were carried out in Cameroon according to a quality control strategy, with the measured parameter values compared to the appropriate acceptance limits .

Literature Review:

Quality control

A quality assurance (QA) software in diagnostic imaging is defined by the World Health Institution (WHO) as an organised effort by the organizations working a factory to ensure that the clinical images produced are also of sufficient high quality to regularly deliver adequate clinical information at the least total price although with the lowest potential patient exposure.

Both quality control (QC) methodologies and quality administration processes are included in quality assurance actions. Quality control techniques including those employed in the monitoring (or testing) and maintenance of the technical aspects or components of an X-ray system are usually included in the QA programme. As a result, the quality control approaches are directly concerned with the equipment that might impact the picture quality, i.e. the component of the QA programme that deals with instruments and equipment. The basic purpose of a quality control programme is to guarantee that the diagnosis or intervention is accurate (optimising the outcome) while reducing the radiation dosage. [49-61].

To achieve that objective in a typical diagnostic radiology facility, QC procedures may include the following:

a. Activation and acceptance testing New equipment is subjected to an acceptance test to ensure that it meets the manufacturer's standards and requirements.

b. Constancy tests are run at regular intervals to ensure that some important parameters are performing as expected. The control of consistency frequencies stated may have a tolerance of 30 days.

c. Status tests are normally performed with full testing at longer periods, e.g. annually.

d. Performance tests are specific tests performed on an X-Ray system after a pre-determined period of time.

e. Verification of radiation protection (RP) and QC equipment and material.

f. Follow-up on any essential remedial steps done as a result of earlier QC processes' outcomes.

The most often used instrument in the detection of illnesses is X-ray, which accounts for a significant portion of man's exposure to artificial resources. In medicine, X-ray imaging is an effective diagnostic tool for which there is no acceptable substitute. X-ray exams should deliver pictures containing significant diagnostic information with the lowest possible radiation dosage, according to the idea of "as low as reasonably feasible" (ALARA). [62].

Some legislative bodies have created quality assurance procedures in hospital medical imaging departments to attain this purpose. According to the Atomic Energy Organization's (AEO) official data, 18,867,000 x-ray exams were performed on 12,963,000 patients in 2003 3)

Medical practitioners' increasing need for x-rays has resulted in unnecessary patient exposure. Routine quality control tests (daily, weekly, and monthly) are not conducted on a regular basis in any radiology department. In light of the significance of QC testing in terms of patient radiation exposure.[63]

Material and methods

Study objectives Amis:

Parameter comparison with standard AAPM74and then degree of exposure time, also we will use standard of tube output reproducibility, linearity, filtration, and beam alignment will be performed and evaluated

X-ray QA Instruments

RaySafe X2 combines state-of-the-art sensor technology with a completely new user interface, making X2 the ultimate in x-ray measurement systems.

- Large touch-screen display for simple operation and great overview of all measured parameters.
- Full waveforms directly in the base unit for quick analysis of measurements.
- No special settings to handle different types of X-ray machines. Just connect and measure.
- Built-in memory – up to 10 000 measurements with waveforms are stored in the base unit.

RaySafe ThinX has been optimized to meet the need for a basic multi-parameter instrument for simultaneous measurement of dose, dose rate, kVp, HVL, exposure time and pulses. All parameters are conveniently displayed in the large LCD.

- Provides a fully automatic user interface
- Perfect choice for radiation measurements in radiographic applications
- Packed with world-leading, state-of-the-art technology to make your measurements effortless

The pocket-sized RaySafe DXR+ operates down to 30 kVp and gives an objective, reproducible and immediate read-out.

- Fully automatic
- Radiographic and Mammography
- Ideal for digital imaging
- 6 - 8 years battery life

5. Examination

Voltage accuracy:

Voltage reproducibility:

Exposure time accuracy:

Exposure time reproducibility: The linearity of tube output (D=f(s)):

The linearity of tube output (D=f (mA)):

Tube output (70 kV at FSD=100 cm):

Reproducibility of the tube output:

Beam alignment:

Parameters	Definition	Good	Normal	Poor

Voltage accuracy	$\frac{\mathrm{Kv(measured)} - Kv(nomiral)}{Kv(nomiral)}$	$\pm 5\%$	$\pm 10\%$	$\pm 10\%$
Voltage Reproducibility	$SD = \sqrt{\frac{\sum(X_i - X^-)^2}{B-1}}$ $CV = \frac{SD}{X^-}$	$\pm 5\%$	$\pm 10\%$	$\pm 10\%$
Exposure time Accuracy	$\frac{time\ (measured) - time\ (nominal)}{time\ (nomainal)}$	$\pm 5\%$	$\pm 10\%$	$\pm 10\%$
Exposure time Reproducibility	$SD = \sqrt{\frac{\sum(X_i - X^-)^2}{B-1}}$ $X = \frac{Dose}{mAs}$	$\pm 5\%$	$\pm 10\%$	$\pm 10\%$
Tube output linearity (D=F(s))	$L = \frac{X_1 - X_2}{X_1 + X_2}$ $X = \frac{Dose}{mAs}$	$\pm 5\%$	$\pm 10\%$	$\pm 10\%$
Tube output linearity (D=F(mA))	$L = \frac{X_1 - X_2}{X_1 + X_2}$ $X = \frac{Dose}{mAs}$	$\pm 5\%$	$\pm 10\%$	$\pm 10\%$
Filtration (HVL)	Thickness of aluminum filter reducing X-ray intensity to half	$> 2.5mmAl$	-	$> 2.5mmAl$
Tube output (70 $Kv\ at\ FSD = 100\ cm$)	$X = \frac{Dose}{mAs}$	43-52	26 -43,	$< 26\ \mu Gy/mAs$
		$\mu Gy/mAs$	$< 52 - 69\ \mu Gy/mAs$	$< 69\ \mu Gy/mAs$
Tube output Reproducibility	$SD = \sqrt{\frac{\sum(X_i - X^-)^2}{B-1}}$ $CV = \frac{SD}{X^-}$	$\pm 5\%$	$\pm 10\%$	$\pm 10\%$
Beam alignment	The distance between light and x-ray field	$< 1\%$	$< 2\%$	$< 2\%$

Table 1. The definition and grading of the most important parameters for QC evaluation of conventional radiology units

Study Subjects: Our target is a optimization of radiation X-ray dose and risk estimation for patients. We will use (the cat tools) for standard quality control assessment tests that will be performed in this study, which include voltage accuracy as the first test

Study Area/Setting: it will be conducted at X-ray Machines radiology department in Maternity and Children Hospital

Study Design: It is a retrospective study by utilizing the software (raysafe for Measurements) and phantoms.

Sample Size: 6 X-ray Machines at radiology department

Sampling Technique: Data will be collected Radiation dose by scanning devices at different doses. We will use standard quality control assessment tests that will be performed in this study, which include voltage accuracy as the first test, and reproducibility, then degree of exposure time, also we will use standard of tube output reproducibility, linearity, filtration,

.Statistical analyses

Continuous variables were presented as mean and standard deviation if are normally distributed or median and interquartile range if their distribution is skewed.

Results and discussion

Machine Equipment

1. Physical Inspection:

1. Physical Inspection:	
	Result
	PASS
2. Source to image Distance Indicator Present and ccurate	PASS
3. If filters can be removed there should be a visible indicator of filter absence	PASS
4. Tube perpendicularity indicator is present	PASS
5. Tube angulation indicator is present	PASS
6. Locking devices are effective.	PASS

7. The light beam is switched off automatically.	PASS
8. The diaphragm can be closed completely.	PASS
9 Tubeheads and supports are smooth and easy to use	PASS
10. Table Bucky lock is functioning properly	PASS
11. Table Bucky Cassette lock holds cassette firmly	PASS
12. Stand Bucky is functioning properly.	PASS
13. Stand Bucky cassette lock holds cassette firmly.	PASS
14. Cable covering are intact.	PASS
15. AEC detector positions are clearly marked and visible.	PASS

2. X-ray Control Panel:

2. X-ray Control Panel:	**Result**
1. There is visible light on 'prepare' and expose"	PASS
2. If more than one tube is used from the panel, the tube selector switches should be labeled.	PASS
3. Panel indicators are functioning correctly.	PASS
4. Control buttons are functioning correctly.	PASS
5. The radiographer has a clear view of the table and chest stand from the panel.	PASS
6. Tube overload protection circuit is working properly	PASS

3. kVp Accuracy & Reproducibility

FDD = 100 cm				**mAs = 20**		**Focus = BF**	
KVp Accuracy							Reproducibility
Set kV	Measured kVp			Average	Accuracy %	SD	Coefficient of Variation
60	59.4			59.4	-1		
70	69.1			69.1	-1.2857		
81	80.3	80.3	80.4	80.3333	-0.823	0.05774	0.000718693
90	89.5			89.5	-0.5556		
102	102.1			102.1	0.09804		
Result					**PASS**		**PASS**

FDD = 100 cm				**mAs = 20**		**Focus = FF**	
KVp Accuracy							Reproducibility
Set kV	Measured kVp			Average	Accuracy %	SD	Coefficient of Variation
60	59.3			59.3	-1.1667		
70	69.3			69.3	-1		
81	80.4	80.4	80.5	80.4333	-0.6996	0.05774	0.0007178

90	89.7	89.7	-0.3333		
102	102.4	102.4	0.39216		
Result		**PASS**			**PASS**

Results:

kVp Accuracy is within accepted limits

kVp Reproducibility is within accepted .

3. Expousre Timer Accuracy & Reproducibility

FDD = 100 cm kV = 81

KVp Accuracy						Reproducibility	
Set ms	Measured ms			Average	Accuracy %	SD	Coefficient of Variation
25	24.4			24.4	-2.4		
50	48.9			48.9	-2.2		
100	97.8	98.8	97.9	98.16667	-1.83333	0.550757	0.005610428
200	195.9			195.9	-2.05		
400	392.3			392.3	-1.925		
Result					PASS		PASS

Results:

mSec Accuracy is within accepted limits

mSec Reproducibility is within accepted .

Reference :

AAPM Report Number 74 , 2002

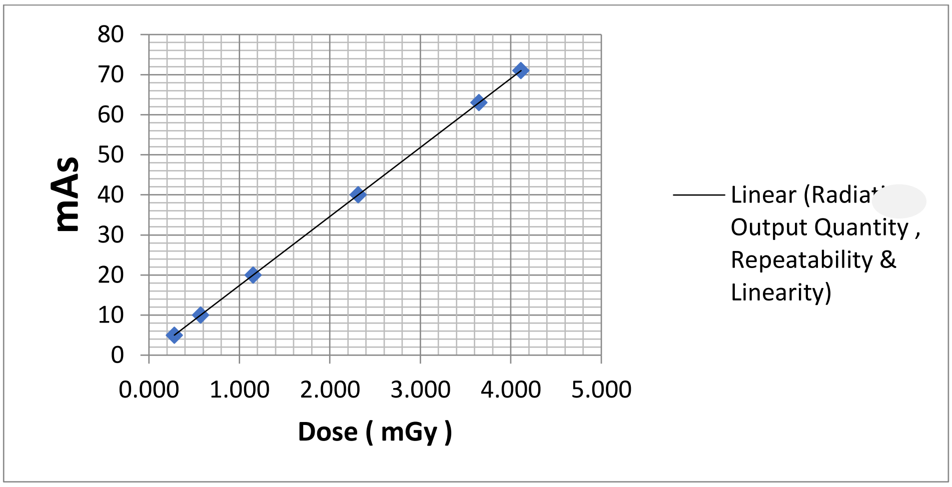
Criteria: Timer Accuracy (+/-) 5 % (For times > 10 msec)
Timer Accuracy (+/-) 10 % (For times < 10 msec)
Expousre Timer Reproducibility less than 0.05

4. Radiation Output Quantity , Repeatability & Linearity

FDD = 100 cm	**kVp = 81**			**Focus = BF**				
mAs (output) Linearity						Linearity	Repeatability	
Set mAs	Measured Dose (mGy)			Average	mGy/mAs		SD	Coefficient of Variation
5	0.2814			0.2814	0.05628	0.014443		
10	0.571			0.571	0.0571			
20	1.154	1.15	1.151	1.151667	0.057583		0.002082	0.001807525

40	2.313			2.313	0.057825			
63	3.649			3.649	0.057921			
71	4.113			4.113	0.05793			
Result						PASS		PASS

$$Linearity\ Coefficient = \frac{(max\ value\ of\ output - min\ value\ of\ output)}{(max\ valueof\ output + min\ value\ of\ output)}$$



FDD = 100 cm			kVp = 81		Focus = BF			
mAs (output) Linearity					Linearity	Repeatability		
Set mAs	Measured Dose (mGy)			Average	mGy/mAs		SD	Coefficient of Variation
5	0.2765			0.2765	0.0553	0.03249		
10	0.5613			0.5613	0.05613			
20	1.128	1.13	1.13	1.129333	0.056467		0.001155	0.001022462
40	2.266			2.266	0.05665			
63	3.57			3.57	0.056667			
71	4.19			4.19	0.059014			
Result						PASS		PASS

Results:

Linearity coefficient is within accepted limits

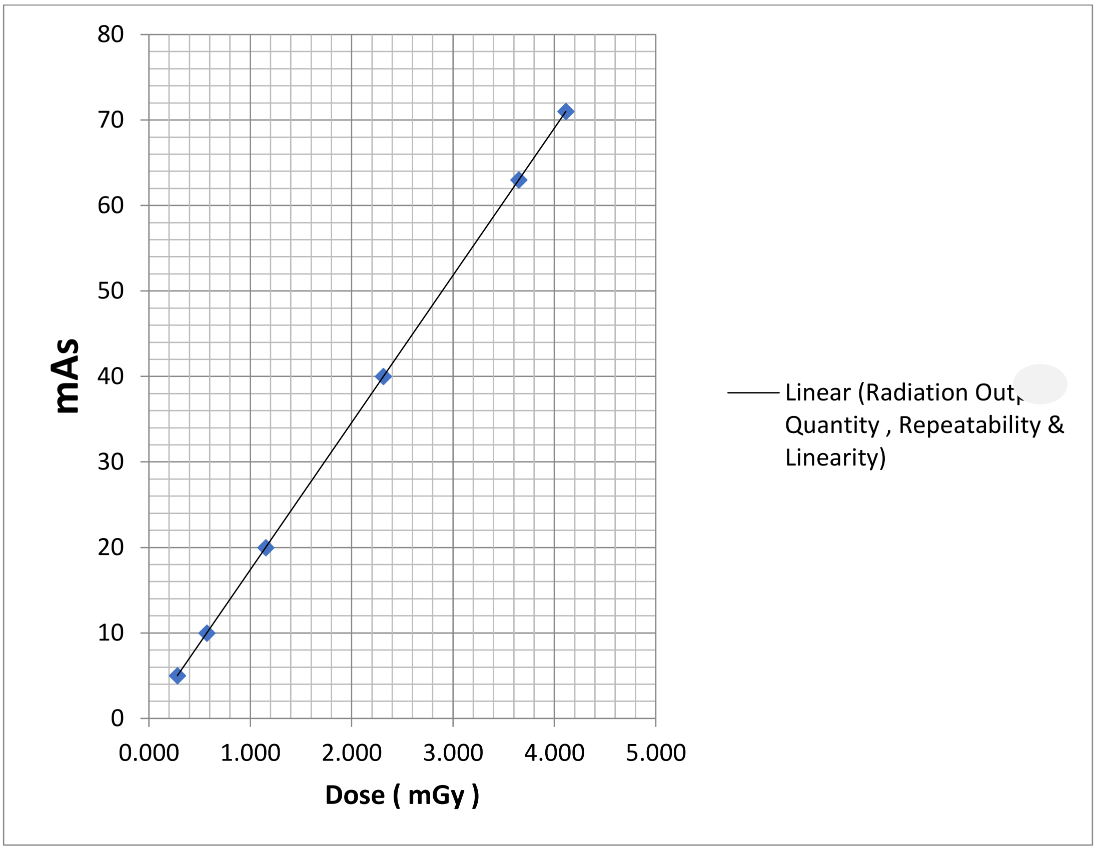
Reproducibility is within accepted limits

Reference :

AAPM Report Number 74 , 2002

Criteria: Linearity cofficient < 0.10

Reproducibility less than 0.05



5. Beam Quality Half Value Layer (HVL)

FDD = 100 cm	kVp = 81	mAs = 20	Focus = BF	
Thickness (d) mmAl	D 0 (mGy)	D (mGy)	% Transmission	
0	1.166	1.166	100	HVL by Equation = **3.3**
1	1.166	0.9061	78	
4	1.166	0.5137	44	
HVL = 3.3 mmAL				
TEST RESULT IS ACCEPTABLE:			**PASS**	

FDD = 100 cm	kVp = 81	mAs = 20	Focus = FF	
Thickness (d) mmAl	D 0 (mGy)	D (mGy)	% Transmission	
0	1.174	1.174	100	HVL by Equation = **3.9**
1	1.174	0.946	81	
4	1.174	0.573	49	
HVL = 3.9 mmAL				
TEST RESULT IS ACCEPTABLE:			**PASS**	

Results:
HVL is within accepted limits

Reference :

AAPM Report Number 74 , 2002
Criteria: HVL > 2.5 mm Al

6. Radiographic Collimation & SID

FDD = 100 cm kVp = 81 mAs = 10 Focus = BF

	Anode (+)	Cathode (-)	Front	Back
Differ (cm)	0.5	0	-0.2	-0.6
Total	0.5		-0.8	
Result	**PASS**		**PASS**	

Result = PASS

Reference :

AAPM Report Number 74 , 2002

Criteria: X-ray field and light fild boaders agree

7. Image Quality & Resolution

FDD = 100 cm kVp = 60 mAs = 10 Focus = BF

Low Contrast	5
Dynamic range	5
Resolution	2.6

Result = PASS

Conclusions

Although various laws govern the use of radiation in medicine, the legal framework does not include the areas of quality assurance and quality control. In light of this, various international recommendations are employed in addition to legal texts. Despite this, there are still many parts of our approach that are unsatisfying. As a result, patient dosimetry and picture quality must be included in the quality management system that should be in place in every diagnostic radiology department

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