Hosted by Ankara University

Journal of Nuclear Sciences

p-ISSN: 2147-7736, e-ISSN:2148-3981

Journal homepage: http://jns.ankara.edu.tr/

DOI: 10.1501/nuclear_0000000019

Assessment of Regulatory Requirements in Diagnostic X-Ray Facilities in Bangladesh

A. Aktar[1*], M. Haider[1], S.M. Islam[2]

[1]Bangladesh Atomic Energy Regulatory Authority, E-12/A, Agargaon, Dhaka-1207, Bangladesh
[2]Department of Physics, Jahangirnagar University, Savar, Dhaka, Bangladesh

Received 03.09.2016; received in revised form 19.11.2016; accepted 25.12.2016

ABSTRACT

X-ray imaging is one of the very old powerful modalities of diagnostic procedures. Bangladesh has a history of over 80 years of using X-rays for medical diagnostic purposes. But many of the users do not have enough knowledge about the potential risks associated with ionizing radiation like X-ray. To create awareness on radiation safety, Bangladesh Government for the first time promulgated nuclear safety and radiation control (NSRC) act in 1993 and corresponding NSRC regulation in 1997. The purpose of the current study is to evaluate shielding structure of some diagnostic x-ray facilities in Jessore district of Bangladesh with respect to regulatory standards. Radiation dose levels are also measured at different points in order to investigate the shielding adequacy of the facility. Estimated dose levels were found higher than the regulatory limit (0.5μSv/h) across the entrance door (ED) of 66% facilities. Secondary walls of the X-ray room were found adequately shielded with 10 inch brick wall. The shielding structure of control panel (CP) of the four facilities was not sufficient according to regulation and there was no shielding in the viewing window of CP of two facilities and the lead shielding thickness at the same points of two other facilities was found less than the regulatory requirement 2 mm lead thickness. Only 4 X-ray operators hold a qualified diploma as radiographer among 16 operators which could affect overall radiation safety features.

Keywords: NSRC regulation, Dose levels, Shielding structure, Viewing window, Radiation safety

1. Introduction

In medical diagnostic procedure, X-ray imaging is still playing a very important role all over the world. The use of X-rays is gaining more priority than the other imaging systems particularly for its simple operational and decommissioning techniques. The increasing number of X-ray facilities in Bangladesh is faster now than before as the economy is expanding and as the people is becoming more and more health conscious [1]. The application of X-rays may cause harm to patients, operators, personnel and the general public individuals if sufficient protection is not arranged in the facility [2].

Shielding design for an X-ray facility is crucial to control the exposure for the concerned people. For shielding calculation of an X-ray room different methodologies (IAEA, NCRP etc.) are available [3, 4]. It can be said that in Bangladesh most of the facilities have been established without performing shielding calculations. Therefore, for obtaining a license from regulatory authority a significant amount of structural change is needed to meet regulatory demand. To support the radiation users, NSRC regulation and guides highlight some shielding aspects which are required to follow the regulation requirements to operate an X-ray facility. According to International Commission on Radiological Protection (ICRP), the principles of radiation protection

*Corresponding author.
E-mail address: arfinaktar1000@gmail.com (A. Aktar)
Journal of Nuclear Sciences, Vol. 3, No.2, Dec 2016, 45-49

ISSN: 2148-7736

requirements lie on the main three basic pillars such as justification of practices, optimization of protection and safety, dose limitation. The concept of justification of practice reflects the use of radiation that must offset the radiation harm that it might cause. The number of individuals exposed, the magnitude of individual doses and the likelihood of incurring exposures require assessing by following ALARA principle in order to optimize protection and safety. On the other hand, occupational dose deterministic effects can be limited by dose reduction techniques. But still there is a potential for having stochastic effect from low exposure from an X-ray facility. The level of radiation dose to radiation workers, patients and the public individuals depends on the quality of the machine, design of the facility, the procedures followed to take images, capability of persons running the practice and the overall management status of the X-ray facility. For controlling deterministic effects of radiation ICRP recommended annual effective dose limit is 20 mSv/y for the operators and 1mSv/y for public, respectively [5]. Personnel monitoring badge (TLD) provides accumulated dose level for the radiation worker [6]. However, non-trained radiation workers in the facilities do not use TLD badges during operation of the machine because there is lack of sufficient knowledge about radiation protection.

There is no quality control (QC) program for X-ray systems which is essential to assess the their performance hence to reduce the emission of leakage radiation level [7].

In the present study, the radiation safety condition of facilities mentioned above will be verified by evaluating the wall thickness, control panel barrier's thickness and type of the shielding material and its thickness used in entrance door. At the same time, experience of the operator for operating machine will also be assessed in this study.

2. Materials and methods

There were 9 diagnostic X-ray facilities randomly chosen in Jessore city for the study. For collection of data an investigation checklist was prepared. This checklist mainly includes machine inputs, model, manufacturer, aluminum filtration, room design, shielding parameters and radiation dose measurement at different location etc. The shielding condition of entrance door, control panel and surrounding walls were assessed. For radiation measurement two GM type dose rate meters were utilized. For precision of the findings, mean values were recorded. Before using the instruments were calibrated in secondary standard dosimetry laboratory at Atomic Energy Research Establishment (AERE), Savar, Dhaka. The calibrating source was a gamma emitting isotope (^{137}Cs) but radiation dose due to X-ray irradiations were measured in diagnostic imaging. This also needs to calibrate the detectors by use of some standard X-ray beam qualities other than ISO ^{137}Cs (0.662MeV) sources. Due to that discrepancy some deviation in the findings may occur. Same kind of two radiation dose rate meters were utilized for the dose measurements for precision of the reading. Dose rate was measured for chest X-ray, lumbar spine, KUB, thoracic spine, skull, knee and PNS. For the experiment, tube potential ranged from 55 to 125 kVp, tube current of 20 to 300 mA and exposure time of 0.5 to 5 s were selected. Radiation dose were measured across entrance door, control panel, primary and secondary walls. Among the different studies chest X-rays were preferred for the dose measurements of the primary wall because the direction of the tube points towards the wall during chest X-ray. Dose rate was measured across the entrance door because patient accompanist persons from public are waiting in places where locate near the door of the facilities. Physician and other staff sitting room was found near primary wall in the 5 (five) facilities coded as 05, as shown in Fig.3. The medical staff were not involved in radiological activities. Therefore, this location across the primary wall was also one of the points of dose rate measurement. For occupational exposure assessment, dose rate was measured behind the control panel barrier. During investigation of X-ray room, room size and shape were also assessed. Information about academic/training qualification and experience of X-ray radiographer were also evaluated in this study.

3. Regulatory requirements

There are three standards available for controlling radiation related activities in Bangladesh. Among them Bangladesh Atomic Energy Regulatory (BAER) Act in 2012, Nuclear Safety and Radiation Control (NSRC) Regulation in 1997 and regulatory guide on radiation protection in medical diagnostic X-rays in 2002 were established [8, 9, 10]. According to these standards the dose limits are 20 mSv per year for occupational and 1 mSv per year for public. Regarding the facility structure, 25.4cm(10-inch) brick wall or equivalent amount of concrete wall and 2 mm lead or 3 mm mild or stainless steel are recommended for shielding of doors/windows for the diagnostic X-ray facilities. According to the guide lines of Atomic Energy Regulatory Board (AERB) of India, 20.32cm (8-inch) brick wall is required for the shielding of an X-ray room and 1.5 mm lead required for door shielding for general radiographic room. In Bangladesh, there are various categories of bricks available. Their density varies significantly. For this reason, little higher thickness of brick is recommended than AERB for developing a barrier of brick for radiation protection. The qualification of radiation worker has been mentioned in the standard as diploma in radiography after completion of secondary education. Appointment of a radiation control officer (RCO) is another requirement for the operation of an X-ray facility [11].

4. Results and conclusion

4.1 Estimation of radiation levels

Fig.1 shows that operators are receiving doses more than their limit 10µSv/h in the 3 facilities out of the 8 facilities. In other words, 40 % of the total facilities do not comply with regulatory requirements in regard to dose limit for the occupational workers. In 66% of facilities, the amount of radiation that penetrate through the entrance door is more than the corresponding limit (0.5 µSv/h) for the public. The area outside the X-room is identified as supervised area where public dose limit is applicable. In most of the facilities radiation is not shielded adequately at entrance doors due to insufficient shielding. Primary and most of the secondary walls of the X-ray room have been established based on the standards. X-ray rooms are structured with 10-inch brick wall which is the requirement of the standards. As a result, radiation doses hardly penetrate through the walls of the facilities [3].

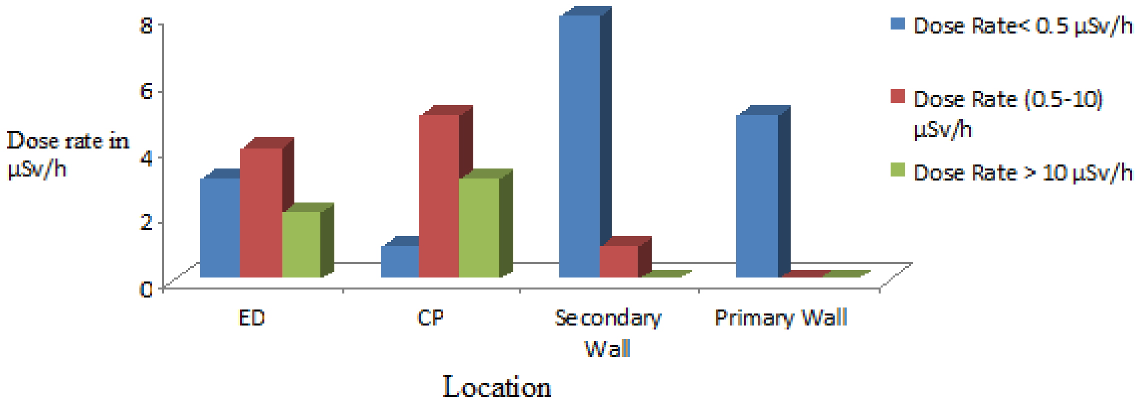

Fig.1 *Measurement of radiation dose rate across shielding materials*

4.2 Assessment of shielding materials

Wood, lead, thaiglass and bricks are used mostly as shielding materials of the X-ray room. According to standard, wood and thaiglass are not recommended as shielding materials for X-ray room because these materials do not provide any shielding for X-ray radiation. But in three facilities these materials are still being used as shielding materials at entrance door of the X-ray room. Therefore, radiation does likely penetrate through the entrance door and thus public might be exposed to unwanted radiation.

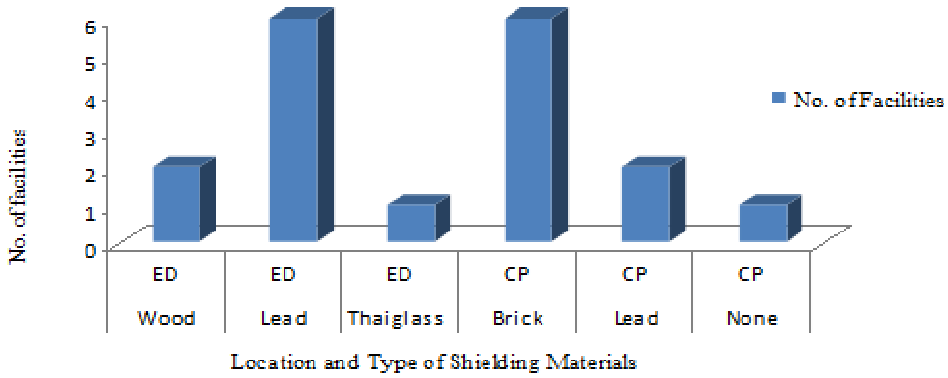

Fig.2 *Description of shielding materials used in X-ray facilities*

4.3 Selection of X-ray tube ratings

In the present study, it has been observed in practice that for the same type of patient study using the same kind of X-ray tubes for the same type of body's structure different kVp, mA and exposure time are chosen by the operators in different facilities. Even for the same patient, different operators select different input parameters for the exposure. Fig.3 shows variations of kVp, mA and exposure time for lumbarspine (LS) study. Maximum current value was selected as 200 mA and minimum as 60 mA. In case of tube voltage, maximum 125 kVp and minimum 55 kVp were set up for the patient exposure. The time of exposure varied from 0.1 s to 4 s. This type of dissimilarities in selecting X-ray tube's parameters may happen due to the unqualified radiographer and lack of awareness on radiation safety of the operator.

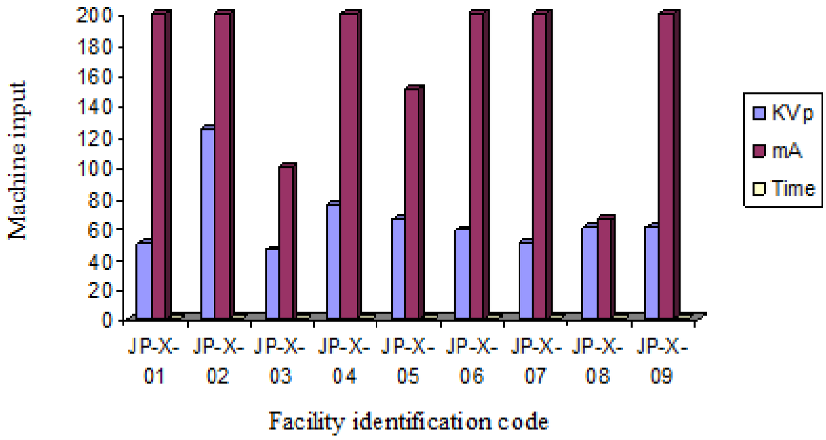

Fig.3 *Assessment of X-ray tubes input settings*

5. Conclusion

Shielding structure of control panel barrier and entrance door of the diagnostic X-ray facilities is not up to the standard. Many facilities were established without following regulatory guidelines. In most of the diagnostic X-ray facilities, the owner of the facility started working on the shielding structure after installation of an X-ray system which is unrealistic and increases the shielding cost as well. As a result, higher radiation dose is being received by the occupational workers and the public. The radiation safety condition is getting worse in the facilities due to the poor condition of shielding structure and lack of qualified operator for operating the X-ray systems. Therefore, stringent regulatory control and cooperation from the radiation users can only improve the present radiation safety situation in Bangladesh.

Acknowledgment

Authors would like to thank scientists/experimental officer of Bangladesh Atomic Energy Regulatory Authority (BAERA) who helped the work during collection of data from radiation facilities. Authors are particularly grateful to Prof. Dr. Naiyuum Choudhury, Chairman, BAERA for his tremendous support to carry out the work.

Conflicts of Interest

The authors have no conflict of interest.

References

[1] NSRC, "Main Report on Regulatory Survey-Inspection of Diagnostic X-ray Machines in Bangladesh", NSRC, Vol-1 (2001).

[2] Haider, M., Hannan, A., Akramuzzaman, M., "Radiation safety aspects in diagnostix X-ray facilities in Bangladesh'. J. Nucl.Med. 13 109-113 (2010).

[3] NCRP Publication 49. "Structural Shielding Design and Evaluation of Medical Diagnostic X-rays and Gamma rays of Energies up to 10 MeV." NCRP Rep.49, (1976).

[4] NCRP Publication 147. "Structural Shielding Design for Medical use of X-rays Imaging Facilities." NCRP Rep. 147, (2004).

[5] IAEA Safety Series No. 115. "International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources". International Atomic Energy Agency, VIENNA, (1996).

[6] H. Cember, T.E. Johnson, "Introduction to health physics", McGraw-Hill (2008).

[7] Adhikari P. Kanchan, Jha. L.N., Galan P. Montenegro. "Status of radiation protection at different hospitals in Nepal." J Med Phys. 37. 240-244 (2012).

[8] BAER Act 2012. "Bangladesh Atomic Energy Regulatory Act for controlling radiation and nuclear related activities", Law no. 19, (2012).

[9] NSRC Regulation 1997. "Requirements of radiation shielding according to Nuclear Safety and Radiation Control Regulation. Bangladesh Government Official Gazette, SRO No. 205, (1997).

[10] NSRC publication 2002. "Regulatory guide on radiation protection in medical diagnostic X-ray". NSRC-XR-G-01, ISBN 984-32-0671-1 (2002).

[11] Oluwafisoye, P.A., Obed, I.R., Bisi-Johnson, M.A., Olowookere, C.J., Popoola, A.O., Efunwole, H.O. "Environmental assessment, instrumentation-quality tests of radiological equipment and human health implications." Sci. Res. Essays 8(46), 2276-2280 (2013).