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ARTICLE

Radiological Safety Survey of Diagnostic Medical X-ray Machines Use in Private and Public Medical Facilities in Malaysia

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A radiological safety survey has been carried out on 100 medical X-ray machines installed in public and private medical facilities throughout Malaysia. The main objective of the survey is to verify the safety of the machines based on Malaysian Standard MS 838, 1985 (Code of Radiation Protection –Medical X-ray Diagnosis). The measurements on machine performance consisted of operating voltage (kV_p) and exposure (Time, reproducibility and linearity). The X-ray beam properties such as collimation, filtration and leakage (Including scattered radiation outside the operating room) are also measured. Image quality such as resolution, contrast and focal spot size are determined as required by MS 838. Out of 100 machines surveyed, 98% have satisfied the requirement of kV_p accuracy of which maximum deviation should not exceeded 5% or 5 kV (Whichever is greater). Table 1 tabulated the typical results of kV_p accuracy. In term of radiation output, more than 50% of the machines have a deviation of less than 5% and the rest hast the deviation of 6% to 10%. The allowed deviation is 10%. All the machines complied with the leakage and scattered radiation requirements where MS 838 stipulated the value of 100 mR/h and 10 mR/week respectively. Other safety practice such as the availability of red light at the entrance door is 100% complied.

KEYWORDS: radiological safety, X-ray, quality assurance

1. Introduction

X-ray machines used for diagnostic purposes both in government and private medical establishments are proven to be the largest contributor of public exposure to ionizing source. It is estimated that up to 90 % of the public exposure is due to medical exposures[1)]. In Malaysia the medical exposure to the public is subjected to acts and regulations that we have adopted from the International Commission on Radiological Protection (ICRP)[2)] and the International Atomic Energy Agency (IAEA)[3)]. The basic safety standard is gazetted as ACT 304[4)] where various regulations are enforced to ensure the protection of people from exposure to ionizing radiation. The ACT 304 also requires the safety of the radiation source which include quality assurance and the issue of yearly safety certificate. To comply to the licence requirements need the establishment and continued maintenance of quality assurance (QA), periodical monitoring and verification of safety records and enforcement by the authorities. In Malaysia, the enforcement agencies are Atomic Energy Licensing Board (AELB) for non-medical applications and Ministry of Health for medical application.

The main objective of the present work is to determine the percentage of X-ray machines used throughout Malaysia, based on radiation safety parameters as stated in MS 838, that comply to safety working procedures and hence, being able to gauge the safety status of medical X-ray machine in the country.

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2. Experimental methods

The hospitals and clinics chosen in this survey are based on their request to be monitored in order for them to be able to apply for the license from Ministry of Health. We have selected the machines to reflect the distribution throughout Malaysia as shown in **Table 1**.

Table 1 Location and number of X-ray machines surveyed.

Location of Machine	No. of machines surveyed
Kuala Lumpur	20
Kuantan	5
Kuala Terengganu	10
Melaka	4
Kota Bharu	15
Alor Star	5
Kota Kinabalu	3
Pulau Pinang	15
Ipoh	10
Johor Baru	5
Kuching	3

The test equipments include Multifunction Meter (Model RMI 240) and Survey Meter (Fluke Model 451P-RYR**)** and kV meter (Rad Check Plus 06-526). All the meters are calibrated by Nuclear Malaysia and traceable to NIST. For voltage output, all the voltage setting from the lowest to the highest, available are tested. The machine is set to 70 kV and 100mA, Source to Image Distance (SSID) of 100cm for other measurement parameters except for resolution measurement where the voltage is set at 50 kV.

3. Results and Discussion

For testing the kV accuracy, the kV is set from 50 kV to 110 kV at 10 kV intervals and the operating current is 100 mA. **Figure 1** shows the typical kV accuracy plot. The number of machines that conforms to MS 838 is 97% as shown in **Figure 2**. The number of machines having exposure and output linearity that conforms to the standard is indicated in **Figure 3**. There are 2 machines having output linearity out of MS 838 i.e. more than 10% deviation. Typical results of focal spot measurement are given in Table 2. Due to space limitation the results of other parameters measured such as exposure time, collimation, leakage and scattered radiation, and X-ray beam filtration are not shown. **Figure 4** gives the overall compliance of the machines tested.

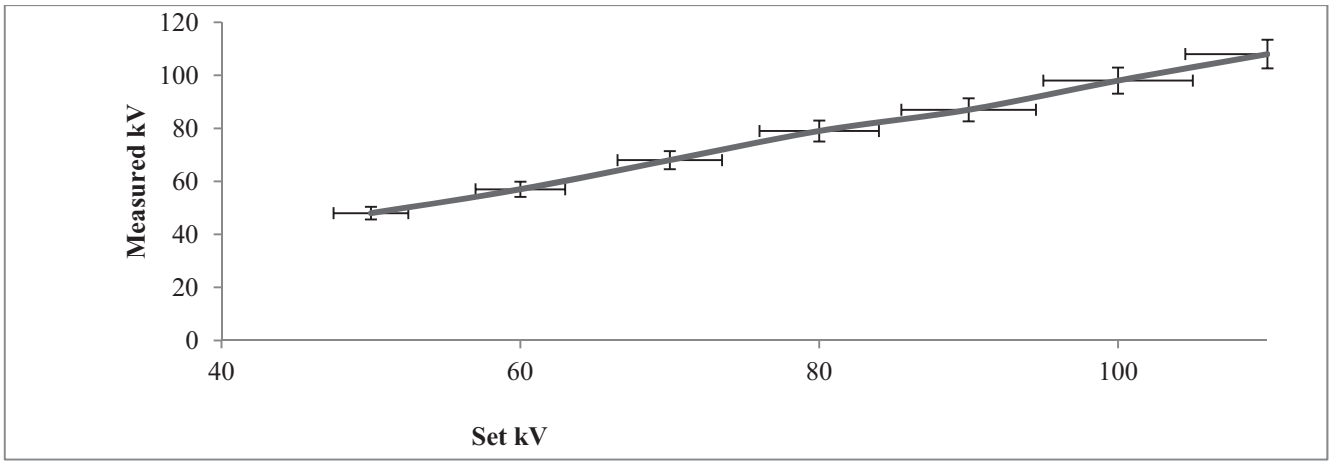

Fig. 1 A plot of set voltage (kV) against measured voltage (kV).

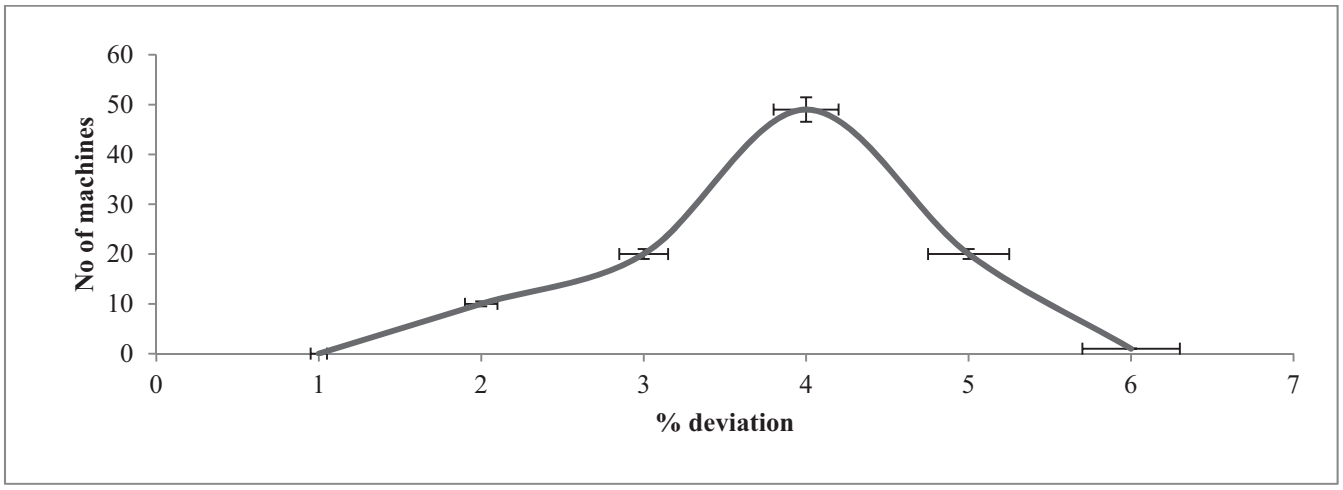

Fig. 2 A plot of no. of machines against deviation (%). Deviation less than 5% comply to MS 388.

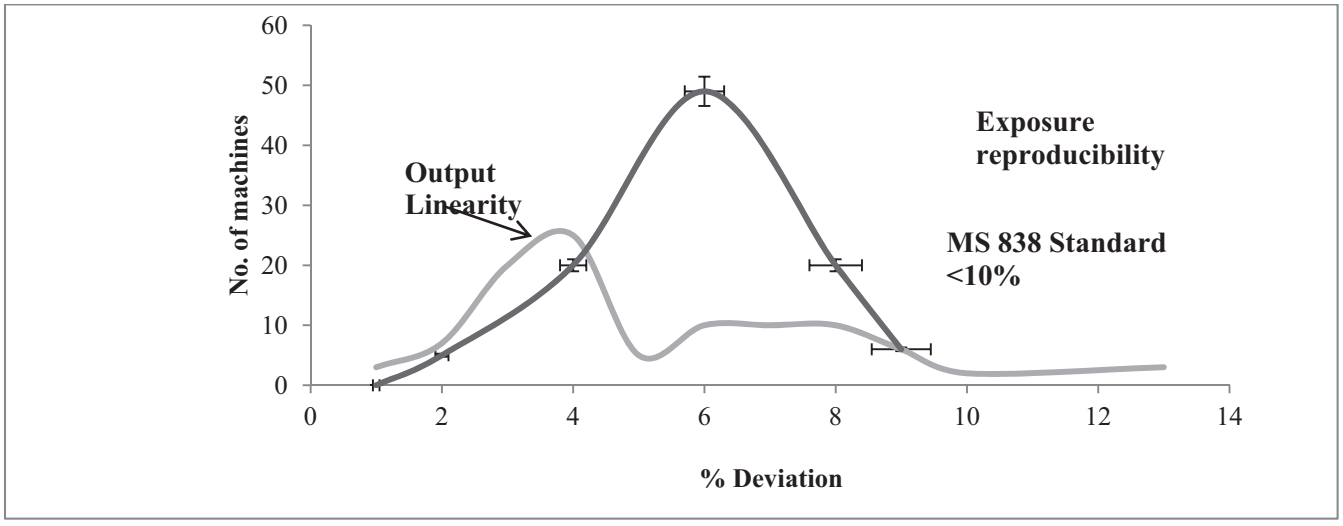

Fig. 3 A plot of no. of machines having exposure reproducibility and output linearity that conforms to MS838.

Table 2 Typical results of focal spot size measurements. Test tool: star test pattern; 40 kV; 0.5 mA; SID 50cm.

Focus	Nominal
Nominal focal spot size (mm)	1.2
Actual diameter of star test pattern (mm)	45
Image diameter of star test pattern (mm)	97
Magnification (M)	2.16
Magnification - 1 (M - 1)	1.16
Measured (mm) $d_{blur, parallel}$	43
Measured (mm) $d_{blur, perpendicular}$	52
Measured focal spot size (mm)$_{, parallel}$	1.30
Measured focal spot size (mm)$_{, perpendicular}$	1.57
Maximum Limit (2 x nominal focal spot)	2.40

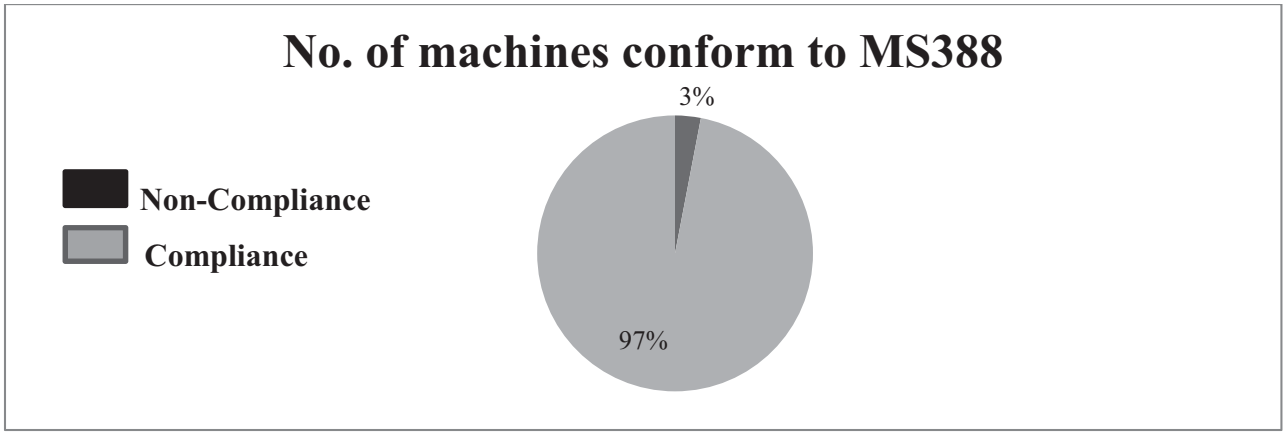

Fig. 4 The overall number of machines that comply to MS 838. Total number of machines is100.

4. Conclusion

Based on the selected machines studied, it is safe to say that the safety performance of the X-ray machines in Malaysia has satisfied the required standard. However to be more accurate, the number of machines surveyed must be increased.

5. References

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