Assessment Of An Instrument For Calibrating Dose Area Product (DAP) Meters

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Introduction

Dose area product (DAP) meters have been installed and used for patient radiation dose assessments from diagnostic radiology procedures for over fifteen years in the UK. The importance of calibrating such devices both on installation and annually was highlighted in the 'National Protocol for Patient Dose Measurements in Diagnostic Radiology' [1]. This protocol also states that "*DAP meters are required to operate under a wide range of exposure conditions and users should satisfy themselves that the meters comply with the tolerances for the complete range of exposure conditions that will be met in practice.*" Since some indication of DAP is now available on a wide range of fluoroscopic and radiographic equipment of widely varying geometry, the calibration is challenging and time consuming. However, guidance on the techniques and practicalities of this sort of calibration is limited.

Radcal Corporation (California, USA) have developed a 'Patient Dose Calibrator', (PDC) designed to allow quick and easy calibration checks of installed DAP meters.

This poster compares the data obtained when checking the calibration of DAP meters using the PDC and North Wales local calibration method.

DAP Meter Calibration Methods

Traditionally our calibration method involved the measurement of the radiation dose at a known distance from the source using a small volume ionisation chamber. We also determined the radiation field size at this distance (using calibrated non-screen film). Since the introduction of CR into North Wales, this method became unworkable due to difficulties defining the field size on the digital image in a manner that was quick to carry out on site. A new method was developed that utilised a range of fixed apertures in sheet lead which were used to limit the radiation field encountered by the DAP meter chamber, (see figure 1a). This method works well for x-ray tubes in over-couch geometry, where it is possible to place the aperture between the X-ray tube and the DAP meter chamber. Other geometries become very time consuming due to problems locating the aperture to accurately determine the field size at the DAP meter chamber. The Patient Dose Calibrator (see figure 1b) eliminates these problems by accurately measuring the dose over the entire beam area – including any non-uniformities, (e.g those due to anode heel effect). This means that it is seeing the same pattern of radiation as the DAP meter chamber and so has the potential to improve calibration accuracy.

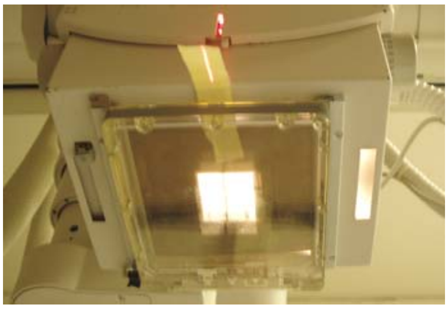

Figure 1a

Lead collimator on X-ray tube to restrict radiation field striking the DAP meter

Figure 1b

PDC in radiation field.

Equipment ID	Equipment Type
1	Mobile radiography unit fitted with external VacuDAP 2000
2	Mobile Image Intensifier fitted with internal PTW DAP chamber
3	Over-couch Fluoroscopy Equipment & Ceiling tube fitted with PTW M2 DAP Meter
4	Radiographic X-ray Equipment fitted with PTW M2 DAP Meter
5	Radiographic X-ray Equipment fitted with PTW M2 DAP Meter
6	Under-couch Fluoroscopy Equipment & Ceiling tube fitted with PTW M4 DAP Meter
7	Angiography C-Arm fitted with internal PTW Chamber

Table 1 - types of X-ray tubes / DAP meters tested.

Equipment ID	Calculated DAP / Installed system DAP	PDC DAP / Installed system DAP
1	1.01	1.01
2 DR pulses Screening	1.10 to 1.20 1.11	1.15 1.14
3 Ceiling tube Over couch screening tube – radiography. Over couch screening tube – screening.	0.99 1.04 1.04	1.01 1.06 1.00
4	0.98	1.01
5	1.04	1.06
6 Ceiling tube Under couch screening tube – radiography Under couch screening tube – screening	1.03 1.16 1.20	1.04 1.11 1.14
7 DR Exposures Screening	0.69 0.72	0.76 0.82

Table 2 - ratio of DAP readings at 80 kV.

Results

Table 1 shows the range of radiological equipment included in this brief evaluation. Table 2 shows the results of the pre-release evaluation and it can be seen that there is generally excellent agreement between the local calibration method and the PDC. Systems that show the largest discrepancies are those where it is not possible to accurately position the lead aperture between the X-ray tube output port and the DAP meter chamber (Systems 2, 6 & 7).

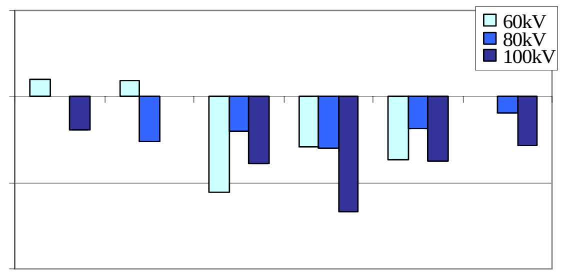

Figure 2 – Ratio of calculated DAP value to PDC indicated value with varying kV.

Figure 2 shows the effect of varying the tube voltage and comparing the calculated DAP value to the PDC indicated value (for radiographic conditions only). It can be seen that for this simple geometry, the results from both methods agree well. Time restrictions and alignment problems encountered using our local method meant that extensive investigation into the response with screening tubes was not carried out. We did briefly look at the response with varying both the field size and shape and found excellent consistency with the PDC. An interesting extension would be to investigate the discrepancies caused when a very non-uniform beam is used.

Conclusion

The PDC method of calibration is significantly quicker than our traditional method, and allows a full check of the DAP meter calibration over a range of field sizes and shapes and beam qualities.

References:

[1] IPSM, NRPB, CoR, National Protocol for Patient Dose Measurements in Diagnostic Radiology, NRPB (1992)