DOSIMETRIC TECHNIQUES FOR MAMMOGRAPHY MASS SCREENING PROGRAMS

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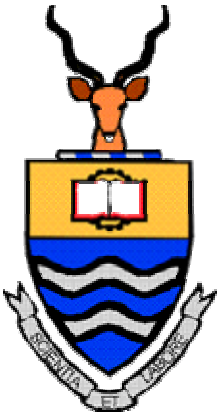

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DECLARATION

I declare that this thesis is my own, unaided work and it has not been submitted before for any degree or examination in any other University. It is being submitted for the degree of Doctor of Philosophy in the University of the Witwatersrand, Johannesburg, South Africa**.**

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ABSTRACT

Screening of asymptomatic women using X-ray mammography technique is very common in many parts of the world in view of the prevalence of breast cancer among women. Mammography X-ray procedures are well established; with radiation dose measurements usually carried out using air ionisation chamber despite its inherent disadvantages. In this study, the various parameters necessary for accurate dose calculations from mammography X-ray energies and their effect on the calculated dose values, the relationship between dose, breast size, image quality and X-ray tube parameters as well as an alternative method for dose measurements, were systematically investigated.

A method is presented for calculating accurately the mass attenuation and mass-energy coefficients for any energy bin of interest in the photon energy region 1-20 keV from existing mass attenuation and mass-energy coefficients data. Data fitting procedure was used for the study using an established equation. The results of the study showed that when data points containing high and low energies such as 1 - 200 keV are fit together with a single set of parameters, an overestimation of about 20% at the lower energies with far greater deviations at higher energies can result. It has been shown that grouping data into smaller energy regions when fitting would lead to accurate calculations of the mass attenuation or mass energy-absorption data. This is especially important if the data were to be used in low energy photon calculations such as would be the case for mammography beams.

An investigation into the effect of pressure, temperature and humidity in air on photon fluence at a typical mammography, low bremsstrahlung energy (25 kVp), has been carried out. The results of the investigation showed that air kerma values from an X-ray spectrum that has significant lower energy components is likely to be more sensitive to changes in pressure, temperature and humidity than the air kerma from an X-ray spectrum with lower energy components less pronounced.

Mean glandular dose (MGD) values had been calculated for various tube potentials and tube loadings (TL) using direct measurements of the incident entrance air kerma (ESAK) at the surface of a standard breast phantom and also from spectral measurements acquired with a solid-state detector. Detailed presentations of dose measurements from direct measurements and also from X-ray spectral data employing the established methods are given. Comparisons of the MGD values thus derived are presented and the relationship between MGD, phantom thickness, image quality and tube operating parameters is discussed.

The possibility of evaluating radiation dose from mammography X-ray beams using constructed probes with diamond as the active radiation sensing material has been studied. Diamond has been used in the conduction mode whereby electrodes are connected to it and the resulting current from the interaction of the ionizing radiation with the diamond detected. Single crystal diamonds produced under high pressure and temperature (HPHT), as well as polycrystalline diamonds manufactured by the chemical vapour deposition (CVD) method were used. Suitable diamond stones were carefully selected for the study using various techniques. The probe was constructed entirely using tissue equivalent

materials. In current practice diamond in the form of thin plates are used in the “flat-on” geometry, where the radiation beam to be monitored or measured, impinges on the flat face of the diamond. In this work it was found that using diamond plates in a side-on, or “edge-on”, geometry improves the collection efficiency of the diamond.

The probe has been designed for radiation detection in both “edge-on” and “flat-on” sensor geometry profiles without having firstly to unseat the diamond sensor element from its original position within the probe housing before taking measurements. The study has shown that with the “edge-on” geometry configuration, radiation from impinging photons with energies below 30 keV can be made to deposit almost all (about 90%) of their energy into the sensor. The probe was designed for use in combination with commercially available electrometer systems. The response of the diamond probe to changes in radiation dose correlated well with that obtained from a secondary standard ionization chamber at the same X-ray tube settings.

I dedicate this thesis to my mother
Rebecca Ntosour
whose love, care and selflessness has brought me this far

to my husband
Francis Boadu

to my son
Michael Kwaku Boadu

and to the everlasting memories of my father
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CONTENT