# DEVELOPMENT AND ANALYSIS OF X-RAY REFERENCE RADIATION BEAM QUALITY PARAMETERS FOR CALIBRATION OF DIAGNOSTIC RADIOLOGICAL EQUIPMENT

**By**

MASINZA, ALWYN STANSLAUS

**BSc (Hons.), PGDSc**

A thesis submitted in partial fulfilment for the award of degree of Master of Science (Physics), University of Nairobi.

December, 2012

## Declaration

This thesis is my own work and has not been examined or submitted for examination in any other university.

**Masinza, Alwyn Stanslaus**
Department of Physics
University of Nairobi.

Signature................................. Date..27TH DECEMBER, 2012

This thesis has been submitted for examination with the approval of my supervisors.

**Dr. Angeyo H. Kalambuka**
Department of Physics
University of Nairobi.

Signature................................. Date..18/01/2013

**Prof. Nimrod Tole**
Department of Diagnostic Imaging and Radiation Medicine
University of Nairobi.

Signature................................. Date 21/01/2013

## Abstract

Kenya has about 3,000 X-ray and 30 Computed Tomography (CT) units. Most of these units (80%) are not calibrated. The remainder are calibrated by use of transfer standards whose calibration status is unknown, hence a broken international traceability chain. Many hospitals and clinics use different radiation qualities and standards, some of which may be unsuitable due to non-calibration after many years of use or replacement of major parts. Where calibrations were actually performed, the test equipment are either not calibrated or sometimes sent out of the country for the service at a considerable cost. For this reason, there is need to establish this capability in the country to bridge this gap.

The objective of the study was to develop reference X-ray radiation beam qualities (RQR) at the Secondary Standards Dosimetry Laboratory (SSDL), KEBS. RQR represent the beam that is incident on a patient when undergoing diagnostic medical examinations and provides diagnostic dosimetry traceability that is presently lacking in Kenya.

Air kerma rates were determined using a one litre reference free in air ionization chamber calibrated at the Primary Standards Dosimetry Laboratory at PTB in Germany. By determination of the Half Value Layers (HVL), narrow series beam qualities meeting the ISO 4037 part 1 criteria were established using high purity aluminium filters placed in the beam. Various RQR were then established using a 30 $cm^3$ Xradin A4 chamber to determine air kerma, HVL and homogeneity coefficient for each beam quality setting.

The results obtained compared to the IEC 61267criteria and were evaluated by use of statistical mean and percentage standard deviations of the measurands, interpolation, ICRP developed formulae and conversion factors taking into account the effect of temperature and pressure to obtain the corrected values of charge produced in ionization chambers.

Compared to the ISO 4037 criteria, the interpolated HVL values were found to be in agreement within the ± 5 % tolerance. The developed reference radiation beams were found to be within the ±3% allowable limits. RQR beam parameters were adjusted by addition of filtration and tested to comply with the IEC 61627 standard criteria. Sources of measurement uncertainties (resolution, calibration, position from tube focus and standard deviation) were identified and estimated. The main source of uncertainty (0.58 %) during the calibration process was found to be due to the ionization chamber positioning set-up.

The established narrow series (N-series) were found to comply with the ISO 4037 requirements within ± 4 %. Subsequent RQR beam parameters established were found to be in agreement with the standard values in IEC 61267 within ± 1 %, within the permissible tolerance limits of ± 3 % for both the homogeneity coefficient and first HVL. All reference radiations were reproduced with success within the IEC tolerance limits. Therefore the SSDL at KEBS can calibrate transfer standards and provide an unbroken chain of traceability.