Calibration of Dosemeters for Radiological Protection

Introduction

The International Organization for Standardization (ISO) 4037 standards [1-3] are the standards applicable for the calibration of dosemeters used for radiological protection. The first three parts of the standards provide the technical details on commissioning a calibration facility for conducting calibrations on those dosemeters commonly used for external dose or dose rate measurements of x and gamma radiations for radiological protection purposes.

ISO Standards

Part 1 of the standards [1] specifies the requirements for establishing the reference radiation fields for the irradiation of the calibrated reference standard which determines the conventional true value of the irradiation dose and for the irradiation of the dosemeter under calibration. The specified reference radiation fields include, *inter alia*, the gamma radiation sources of Am-241, Cs-137 and Co-60 and other filtered x-ray radiation fields.

Part 2 of the standards [2] specifies the dosimetry for determining the dosimetric quantity. Air kerma is one of the common dosimetric quantities used in calibration.

Part 3 of the standards [3] specifies the additional requirements on the calibration of area and personal dosemeters. On-phantom calibrations are required for the calibrations of these types of dosemeters. The standard also specifies the detailed requirements on such phantoms.

Calibration Factor and Uncertainty Evaluation

The quantitative result of the calibration is the calibration factor with the specified uncertainty and test conditions. The calibration factor is the quotient of the conventional true value measured by the calibrated reference standard and the reading of the dosemeter under calibration when irradiated by the same reference radiation field. The ISO 4037 standards specify the standard test conditions for conducting the calibration.

The “ISO guide to the expression of uncertainty in measurement” [4] recommends the approach on evaluating the uncertainty of measurements which is also applicable for the evaluation of the uncertainty on the calibration factor.

The standard uncertainty and the degree of freedom of individual parameter influencing the calibration factor shall be evaluated at the outset. The degree of freedom of the individual parameter is related to the number of measurements taken for and/or the scientifically judged reliability on the measured value of the parameter.

Standard uncertainties and degrees of freedom of all the influencing parameters shall then be combined to obtain the combined standard uncertainty and the effective degree of freedom of the calibration factor.

The effective degree of freedom, together with the required confidence level on the determined calibration factor, will be the inputs to the statistical t-distribution function which will yield the coverage factor (commonly denoted as k) corresponding to the required confidence level.

The expanded uncertainty on the calibration factor will then be given by the product of the combined standard uncertainty and the coverage factor. One of the common confidence level reported in the calibration report/certificate is the 95% confidence level. The corresponding coverage factor will be about 2 but the exact value depends on the evaluated effective degree of freedom.

The calibration factor for the dosemeter under calibration and the corresponding expanded uncertainty at a given confidence level and coverage factor shall be reported in the calibration report/certificate.

The detailed methodology on the evaluation of uncertainty is available in the ISO Guide [4].

Reference

[1] INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy – Part 1: Radiation characteristics and production methods, ISO 4037-1:1996.

[2] INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy – Part 2: Dosimetry for radiation protection over the energy ranges 8 keV to 1.3 MeV and 4 MeV to 9 MeV, ISO 4037-2:1997.

[3] INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy – Part 3: Calibration of area and personal dosemeters and the measurement of their response as a function of energy and angle of incidence, ISO 4037-3:1999.

[4] INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, Guide to the expression of uncertainty in measurement, corrected and reprinted, 1995.