Conversion Factors of Modern Devices Which Can Be Used to Measure Radioactivity in Human Thyroids after Radiation Accidents

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Abstract

As a rule, after radiation accidents concerned with release of iodine isotopes in environment, measurements of radioactivity in human thyroids are made not only with specialized devices but also with usual dosimeters. Such "direct" thyroid measurements were done after the Chernobyl accident as well as after the Fukushima one.

Monte-Carlo models of two modern unspecialized radiometric devices - NaI scintillator based-on radiation monitor AT6101 (probe BDKG-05, SPE "ATOMTEX", Belarus) and organic scintillator based-on dosimeter DKS-96 (SPE "Dose", Russia) have been developed and verified. Dosimeter AT6101 was used for measurements of radioactivity in human thyroids of Japanese people after Fukushima accident. The quantity of interest in analysis of such measurements is a so-called conversion factor (CF), i.e. activity of ^{131}I in thyroid per unit exposure rate. MCNP-based model of measurements of radioactivity in human thyroid with these devices has been developed using family of Oak Ridge National Laboratory (ORNL) phantoms (newborn, children aged 1, 5, 10, 15 years and adults). ORNL phantoms include a rather complicated mathematical model of thyroid in the form of two ellipsoids cut by trachea and connected by isthmus. For calculation of CF quantities of the devices it is necessary to know their sensitivities in terms of deposited in detector energy per unit dose rate. These characteristics of the devices were determined by combining the experimental and theoretical results of measurements of the gamma radiation reference sources at fixed distance between source and detector.

Conversion factors were calculated for reasonable scenario of thyroid measurements when lower point (LP) of the detector coincides with the lower point of the neck. Their age dependence is described by the square-law function which parameters are found for all iodine isotopes of interest.

The CF quantities and their uncertainties caused by errors in the position and orientation of the detectors relative to the thyroid have been analyzed. It has been shown that dependence of conversion factors versus take-off of the device away from the neck or displacement of the device from its LP position along the neck is described by the square-law function which parameters have been determined for both devices.

Conversion factors obtained can be used in analysis of thyroid measurements with these devices.

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KEYWORDS: Chernobyl, Fukushima, thyroid, direct measurement, radioiodine, conversion factor, Monte Carlo, uncertainties

Word count: 363