Dose Evaluation for Internal Contamination by 192Ir

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Abstract. The assessment of committed effective dose in the case of an unusual exposure involving workers to an unknown intake could be a laborious task. Direct or indirect measurements provide information about the amount of radionuclide present in the body, in a biological sample or in a sample from the working environment. The calculation of committed doses from sequential measurements will give information about the total body retention and the biokinetic behavior of radionuclides in the body. The purpose of this work is to provide a general overview of the interpretation of measurements and to illustrate the process of the dose evaluation in the case of an unusual incident exposure with ^{192}Ir contamination. It is likely that the worker exposure had occurred during the opening operation of a shielding with ^{192}Ir disks. A special monitoring was carried out on the whole body measurement laboratory with a NaI(Tl) detector. The initial measurement has indicated a whole body counting of (22.15 ± 0.98) x10^{+3} Bq for ^{192}Ir, approximately 19h after the incident. A follow-up monitoring programme was established for an extended period of 2 months from the incident. The software used in this work to evaluate the internal dose was the Activity and Internal Dose Estimates (AIDE), which include the options to adjust the measured data with the biokinetic models of ICRP. Preliminary committed effective dose evaluation done with single measurement data was bellow the recommended dose limits. The multiple measurements will be used in the interpretation of the results and also to get the best estimate of intake.

KEYWORDS: internal dosimetry; whole body counting; committed dose; biokinetic models.

1. Introduction

The establishment of safety requirements and guidance on occupational radiation protection [1,2,3] is a component of concern for all the installations operated at Nuclear and Energy Research Institute-IPEN. In all these installations an operational radiation protection officer is in charge to establish a routine, task related or a special monitoring of the workers. The assessment of exposure in the workplace is an integral part of the occupational radiation protection programme. The dosimetry laboratory service of IPEN has a direct contribution to this programme for external and internal dose evaluation.

The sealed source production plant for industrial gammagraphy application is one of the installations operated ate IPEN During the production of ^{192}Ir sealed source a deviation of the operational procedure had originate an unexpected contamination. The contamination was detected during the self monitoring procedure carried out by the worker. The radiation protection service of the installation was immediately communicated of the occurrence and the investigation procedure had been started.

An internal monitoring was accomplished approximately 19h after the event by the *In Vivo* Measurement Laboratory. The initial whole body measurement has indicated an internal contamination with ^{192}Ir in the worker. A follow-up monitoring programme was established for an extended period of 2 months from the event.

This work provides a general overview of the interpretation of measurements and illustrates the process of the dose evaluation.

2. Materials and Methods

In general, the dosimetry service has limited direct contact with workers and facility management. Usually, the communications of any relevant dosimetry data are made by the radiation protection staff of the facility. Consequently, close cooperation is needed between those involved in different parts of the monitoring and protection program.

In the case of an unusual event, the radiation protection supervisor makes a contact with the internal dosimetry service notifying the occurrence and seeking for a special monitoring. A preliminary study is made to gather all the information about the event as well as the physical and chemical nature of the radionuclide, the handled activity and the intake pathway.

The internal dosimetry service at IPEN is operated by the *In Vivo* Measurement Laboratory, *In Vitro* Measurement Laboratory and the Dose Evaluation Group and it is well established.

The *In Vivo* Measurement Laboratory is able to measure high-energy photon emitters in the whole body and thyroid. The detection system consists of one NaI(Tl) detector (8 in in diameter x 4 in) for whole-body measurements, connected to a Ortec 556 high-voltage supply, a Camberra 2022 amplifier and an EGG&Ortec 920 Ethernim 16-imput multichannel buffer. The walls of the shielded room consist of 130 mm-thick steel sheet lined with 5 mm of lead and 5 mm of copper. The internal dimensions are 2.6 m x 1.7 m x 1.85 m, with air filtration and maintained at a temperature of 25ºC. The counting time was 15 min. Minimum detectable activity (MDA) values for some radionuclides typically measured with the whole-body counter were calculated as follows: 10 Bq for ^{131}I, 40 Bq for ^{123}I and 70 Bq for ^{99m}Tc [4]. The alpha and beta emitters are measured by bioassay technique.

The software used in this work to evaluate the internal dose was the Activity and Internal Dose Estimates (AIDE) [5], which include the options to adjust the measured data with the biokinetic models of ICRP. The biokinetic model for ^{192}Ir is in accordance with the ICRP-30 [6]and the human respiratory tract follows the ICRP-66 models [7]. The AIDE is programmed with three techniques for estimating intake from multiple bioassay samples. They are: Point Estimates, Unweighted Least Square Fit (ULSF) and Weighted Least Square Fit (WLSF).

3. Results

A special monitoring was carried out on the whole body measurement laboratory with a NaI(Tl) detector. The initial measurement has indicated a whole body counting of (22.15 ± 0.98) x10^{+3} Bq for ^{192}Ir, approximately 19h after the event. A follow-up monitoring programme was established for an extended period of 2 months from the event, as seen in Table 1.

Table 1: Whole body measurement results with a NaI(Tl) detector.

Time after intake (d)	Whole body measurement	
	Activity (Bq)	Std. Dev (Bq)
1	22146	979
15	13488	616
22	10046	474
29	9254	452
36	6422	335
50	6097	319
64	4998	277

According to the available data it was identified as an iridium oxide compound and there was no information about the particle size. The route of entry was assumed to be nose breathing and an acute intake pattern.

Preliminary committed effective dose evaluation with single measurement data had shown bellow the recommended dose limits. The estimated results after 1 day from the event were 4.12×10^{-4} Sv and 2.23×10^{-4} Sv respectively, considering 1.0 μm and 5.0 μm AMAD. A follow-up dose evaluation was carried out and the results after two months for multiple bioassay data are shown in the Table 2.

Table 2: Committed effective dose evaluation with AIDE computer program. The AIDE is programmed with three techniques: Point Estimates, Unweighted Least Square Fit (ULSF) and Weighted Least Square Fit (WLSF). The activity median aerodynamic diameter (AMAD) of 1.0 μm and 5.0 μm was considered.

Estimating techniques	AMAD=1.0 μm		AMAD=5.0 μm	
	Intake (Bq)	E (Sv)	Intake (Bq)	E (Sv)
Point Estimate	1.08×10^{5}	6.94×10^{-4}	1.92×10^{5}	9.40×10^{-4}
ULSF	7.63×10^{4}	4.88×10^{-4}	5.22×10^{4}	2.56×10^{-4}
WLSF	9.38×10^{4}	6.00×10^{-4}	7.47×10^{4}	3.66×10^{-4}

The comparison of the committed effective dose among the data of the Table 2 shows the results for AMAD=1 μm is higher than of AMAD=5.0 μm, except for the point estimate. The committed effective dose evaluated from single measurement data underestimate those from Table 2.

4. Conclusion

The results from multiple measurements present a more realistic estimation of the committed effective dose, meanwhile in this unusual event it has shown well bellow the annual limit established in Radiation Protection Ordinance [8] issued by the brazilian regulatory authority.

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