Evaluation of internal exposure in French nuclear power plants based on whole body counting

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Introduction

At EDF, dose assessments for internal contamination were so far mainly done by biologists using in vitro measurements. Several factors lead to change this practice: French regulations which attribute this assessment to occupational physicians [1], accreditation of whole body measurements which legitimates the use of this type of analysis and the development of Cador, a home-made Excel file [2] which allows to easily perform the assessment. The objective of this work was to estimate the interest of whole body measurements for internal contaminations.

Material and method

An analysis of 149 cases of internal contamination which occurred in French nuclear power plants between 2008 and 2015 was conducted. More than one thousand whole body counting spectrums were treated with double-checking. The analysis was led by the last version of Cador using the French Recommendation of HAS [3] and the Chi-squared test provided by European IDEAS guidelines [4].

Most of the contaminations were situated between 0.1 mSv and 1 mSv. This level corresponds to the intermediate level of the French Recommendations of Good Practice and to the level 1 of the IDEAS guidelines. For this level, an estimation based on a single type of analysis is considered sufficient. In this respect, the assessment might be done with whole body measurements only.

In the Recommendations of Good Practice (RGP) the goodness of fit is considered acceptable if there is no more than a factor 3 between the various estimates of intake. The uncertainties are not taken into account. In the IDEAS guidelines, the goodness of fit between the measures and the model is assessed against a Chi-squared test. This method requires knowing the uncertainties of measures. IDEAS guidelines provide values of

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geometric standard deviation, so called Scattering factors, for various analyses. For whole body measurements of high energy radiation, the Scattering Factor is 1.2.

The first stage refers to RGP method and consists in looking at the gap between the various estimates. The second stage refers to IDEAS method with the Chi-squared test. A coloured rectangle summarizes the results of both methods. The rectangle is green, orange or red depending on whether the fit is good with respectively both methods, any of them or none of them.

Results

30 cases could not be analysed because of an insufficient number of whole body measures. Among 119 remaining cases, 21 cases corresponded to an inhalation model of hot particles where the assessment of activity needed another method [5]. For 32 cases, the activity was too low or the number of measures was insufficient.

For the 66 remaining cases, we were able to exactly identify an incorporation model described by ICRP. RGP and Chi-squared tests were valid in 79% of cases and RGP alone in remaining 21%. The identified models and AMAD observed are shown in table 1.
In an isolated way or not, we found Cobalt 58 in 55% of the cases, Cobalt 60 in 48% of the cases and Argent 110m in 26% of the cases. We also observed Caesium 137, Antimony 124, Zirconium-Niobium 95, Chromium 51 and Manganese 54.

Inhalation : 60 cases (91%)			**Ingestion** : 6 cases (9%)
5 µm AMAD	1 µm AMAD	1 or 5 µm AMAD + hot particles	
30 cases (46%)	22 cases (33%)	8 cases (12%)	

Table 1: models identified by RGP and chi-squared test

Except the cases of inhalation of a hot particle, the evaluation of the incorporated activity by whole body measurements was comparable to faeces analysis in half of cases. In the other half, the estimated activity from faecal examinations was lower than activity estimated by the whole-body measures.

Conclusion

Finally, 34 cases resulted in a committed effective dose superior to 0,1mSv but lower than 0.5mSv. The whole-body measurements allowed the dose assessment if the time of counting and the number of measure are sufficient.

Key words: Occupational medicine, radiation protection, nuclear power plant, internal contamination, whole body measurements, committed effective dose.

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