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Long-term intercomparison of Spanish environmental dosimetry services. Study of transit dose estimations

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Abstract

This paper presents the layout and results of a three-year follow-up of a national intercomparison campaign organized on a voluntary basis among the Spanish Laboratories in charge of environmental monitoring at and in the vicinity of Spanish nuclear installations. The dosemeters were exposed in the field at an environmental reference station with a known ambient dose equivalent, and controlled meteorological parameters. The study aimed at verifying the consistency of the different laboratories in estimating the ambient dose equivalent in realistic fields and to evaluate the influence of two different procedures to estimate the transit dose during the transfer of the dosemeters both from and to the dosimetric laboratory and the monitored site. All the results were within 20% of the reference doses for all the dosemeters tested, and in most cases they were within 10%.

Keywords: Environmental monitoring; Intercomparison; Transit dose

1. Introduction

Environmental monitoring in Spain is mainly performed in the vicinity of nuclear installations. It includes systematic surveys undertaken directly by the owners of the sites and quality control verifications at some selected measuring stations coordinated by the Spanish Nuclear Safety Council, CSN (the authority for Radiation Protection and Nuclear Safety). The CSN is in charge of authorization of the dosimetric services and of surveillance of the environmental programmes. To ensure adequate protection of the population, it periodically audits the services and every 5 years it organizes intercomparisons under controlled conditions at reference calibration laboratories. The last national intercomparison was carried out in 2001 (González and Brosed, 2002). Results highlighted a good performance of the services, which widely fulfilled the ANSI (2001) 13.11 requirements for environmental measurements. However, the laboratory exercise was found to be incomplete for the evaluation of quality of service in realistic fields. It also highlighted significant differences among laboratories regarding the daily dose received during the transit period between the calibration laboratory and the dosimetric services. The correction for transit dose represented a value of between 9% and 35% of the measured environmental dose.

Intercomparisons in real environment fields are needed to investigate special problems related to environmental exposure such as the energy response of environmental dosemeters (Klemic et al., 1999) or transit corrections (Ranogajec et al., 1996). The ISO (2005) 17025 standard for the requirements of calibration and testing laboratories includes the participation in such intercomparisons among its requirements. Unfortunately,

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in 1999, the Environmental Measurements Laboratory of the USA organized the last large-scale international intercomparison of environmental dosemeters with the participation of more than 150 sets of dosemeters. Since then, it has been very difficult to participate in such a study by most of the Spanish Dosimetric Services.

To both improve and harmonise radiological environmental monitoring, the Spanish regulatory body has set up a working group on environmental dosimetry with the commitment to organize an intercomparison in environmental fields. The main assigned tasks were to analyse the consistency of dose estimates in realistic fields and to analyse the influence of transit dose estimates in the evaluation of environmental measurements. The contribution of transit dose to the field dose can be of great importance if the transit period is high compared with the monitoring period (Ranogajec et al., 1996).

This paper presents the layout and results of a three-year follow-up of a national intercomparison organized on a voluntary basis among the Spanish Laboratories in charge of environmental monitoring in the vicinity of Spanish nuclear installations.

2. Set up of the intercomparison

2.1. Monitoring site

The dosemeters were exposed at the Esmeralda Environmental Reference Station of the CIEMAT in Madrid (Sáez-Vergara et al., 1996). The environmental external radiation at the site is continuously monitored by using a Reuter Stokes high pressure ionization chamber (HPIC). Meteorological parameters, radon exhalation, and radioactive aerosols are monitored during exposure with specific instruments. The reference value, $H^*(10)_{\mathrm{Ref}}$, for the intercomparison is the ambient dose equivalent measured with the Reuter Stokes ionization chamber, with a mean value of 155 nSv/h. The uncertainty associated with this value is 6% ($k = 2$). Furthermore, the Esmeralda Station has special cylindrical shielding, 12 cm inner diameter, with 11-cm-thick lead walls, covered by 2 mm Cd and 4.5 mm Cu. The background in the shield was determined by several independent techniques, electronic and passive dosemeters, and is equal to 24 nSv/h, with an estimated uncertainty of 15% ($k = 2$). The shielding stores the dosemeters used for the estimation of the transit dose during exposure of the field dosemeters.

2.2. Participants

Five environmental dosimetry laboratories participated in the intercomparison. Two services sent two types of dosemeters and so a total of seven different dosemeters were evaluated. Table 1 indicates the number of detectors and type of material used by each laboratory. All the dosemeters were based on TLDs: LiF:Mg,Ti (3), LiF:Mg,Cu,P (3), and $CaSO_4$: Tm (1).

Table 1
Main characteristics of the dosemeters

Laboratory code	TL material and number of elements
Lab#1a	6 ^{7}LiF:Mg,Ti detectors
Lab#1b	6 LiF:Mg,Cu,P detectors
Lab#2a	10 LiF:Mg,Ti detectors
Lab#2b	10 LiF:Mg,Cu,P detectors
Lab#3	4 LiF:Mg,Cu,P detectors
Lab#4	3 $CaSO_4$:Tm detectors
Lab#5	3 ^{7}LiF:Mg,Ti detectors and 1 ^{6}LiF:Mg,Ti detector

2.3. Procedures

Each participant sent a set of dosemeters quarterly consisting of a minimum of one dosemeter (labelled as "Field") for field monitoring and one dosemeter (labelled as "Shield") for its storage in the 12-cm lead shield of known background level. Some laboratories were also asked to send an additional dosemeter (labelled as "Trip"), which was immediately returned to the laboratories when the whole set arrived to the CIEMAT station. This dosemeter reading was used to have a direct measurement of the dose received during the transit of the dosemeter from and to the dosimetric laboratory and the environmental station. Only laboratories outside Madrid included this "Trip" dosemeter. All results reported by the participants were in terms of ambient dose equivalent, $H^*(10)$.

When the set of dosemeters arrived at the CIEMAT, the "Field" dosemeter was exposed at 80 cm of the reference ionization chamber, the "Shield" dosemeter located within the shield and, if available, the "Trip" dosemeter was sent back to the dosimetric laboratory. After a 3-month exposure, the dosemeters were sent back to the dosimetric service for evaluation. Simultaneously, the dosimetric services sent a new set for the next period. The study started in 2003 and has been carried out for more than 3 years.

2.4. Dosimetric evaluation

The field dose at the monitoring site determined by the participating laboratories, $H^*(10)_{\mathrm{Lab}}$, was calculated by subtracting the contribution of the transit dose, $H^*(10)_{\mathrm{Transit}}$, to the dose measured by the dosemeters exposed at Esmeralda, $H^*(10)^{\mathrm{Lab}}_{\mathrm{Field\ Dosemeter}}$, as given in the following expression:

$$H^*(10)_{\mathrm{Lab}} = H^*(10)^{\mathrm{Lab}}_{\mathrm{Field\ Dosemeter}} - H^*(10)_{\mathrm{Transit}}. \quad (1)$$

To estimate the transit dose, two different methods are proposed:

(i) the transit dose is calculated from the "Shield" dosemeter reading, $H^*(10)^{\mathrm{Lab}}_{\mathrm{Shield\ Dosemeter}}$, taking into account the dose rate in the shielding and the corresponding storage time (given by the CIEMAT):

$$H^*(10)_{\mathrm{Transit}} = H^*(10)^{\mathrm{Lab}}_{\mathrm{Shield\ Dosemeter}} - \dot{H} * (10)_{\mathrm{Shield\ Background}} \cdot t_{\mathrm{Shield}}, \quad (2)$$

(ii) the transit dose is estimated by means of the "Trip" dosemeter:

$$H^*(10)_{\mathrm{Transit}} = H^*(10)^{\mathrm{Lab}}_{\mathrm{Trip\ Dosemeter}}. \quad (3)$$