Occupational Exposure and Dose Distribution in a Brazilian Radiopharmaceutical Facility

Janete C. G. Carneiro[1], Matias P. Sanches[1], Demerval L. Rodrigues[1]and Gian Maria A. A. Sordi[1]

[1]Instituto de Pesquisas Energéticas e Nucleares, IPEN – CNEN/SP
Av. Prof. Lineu Prestes, 2242 - Cidade Universitária – 05508-000
+55-11-3133-9674 (Phone and Fax)
São Paulo - SP – Brazil

janetegc@ipen.br, msanches@ipen.br, dlrodri@ipen.br, gmsordi@ipen.br

Abstract. The aim of this study is to carry out a retrospective study of occupational doses arising during the year of 2011 in a Brazilian Radiopharmaceutical Facility. The dose distribution was based on a set of requirements established by the National Regulatory Authority. For this purpose, four characteristics of the dose distributions were identified as being; the average annual effective dose, the measurable dose**,** the collective dose distribution ratio**,** and the distribution ratio for the number of exposed workers, according to the reference levels. On the basis of all data reported by the Radiation Protection Office, the occupational doses received by workforce in 2011 were compared with the doses and trends over the past periods.

1 Introduction

The use of radioisotopes in medicine is certainly one of the most important social applications of Nuclear Energy. The Instituto de Pesquisas Energéticas e Nucleares, IPEN - CNEN/SP, is the major Institution in Brazil, in this field of application, and particularly one of its centers, the Radiopharmaceutical Facility, is responsible for the radioisotope production and distribution for use in Nuclear Medicine. The radioisotope production is performed in three main areas: Radioisotopes (Tc-99m generator and primary radioisotopes); labeled compounds and lyophilized Kits for labeling with Tc-99m.

Among the radioisotopes produced, Tc-99m has the main contribution, about 87% of the total activity handled. The remaining, 13% refer to others primary radioiso-

topes. The radiation protection program for the Radiopharmaceuticals Facility in this paper focuses only aspects dealing with the protection of workers. The dose assessment is based on monitoring records of the workplace and individual monitoring for external and internal exposure.

In most situations, doses due to external radiation are assessed routinely by use of a passive Thermoluminescent Dosimeter, TLD, generally used on the body surface by worker for a month period. At the end of this period it is read and the dose recorded. In general, all workers have been monitored for internal exposure using *in vivo* or *in vitro* measurements. The frequency of measurements differs according to the task performed and the work station.

On the basis of all data reported by the Radiation Protection Office, this paper has shown the behaviour of doses received by radiopharmaceutical workforce in 2011. The dose distribution was compared with the occupational dose assessment and trends over the past periods for this facility [1-3].

2 Methodology

2.1 Occupational Exposure Assessment Records

Dose record keeping is an essential part of the individual monitoring process and should be kept up to date and procedures should be established to ensure that assessment of dose from any monitoring period reach the individual´s dose record promptly [4].

Furthermore such data may be used to identify both good and bad features of operating procedures and design characteristics, and thereby contribute to the development of safer radiation working practices.

The reference levels and doses limits adopted in this study are in accordance with the National Regulatory Authority [5], and its application was taken some flexibility, such as:

- 0.2 mSv/month: Recording level
- 6 mSv/year: Investigation level
- 20 mSv: Annual Effective Dose, averaged over five consecutive years
- 50 mSv: Annual Effective Dose Limit in any single year

When the dose exceeds the investigation level it is then required a prompt review of the situation to determine the causes.

2.2 External Radiation Dose

The individual dose records for external radiation are carried out by Thermoluminescent Dosimetry (TLD). In practice, doses lower than the recording level, (0.2 mSv/month), may be recorded as zero. In this case, the recording level was

adopted as Minimum Detection Level (MDL), of the measuring technique by film badges, although the minimum detection limit for TLD is much lower.

When the dosimeters are lost or the readings are not available, the assigned dose to the worker is an appropriate proportion of the annual limit for the period which the dosimeter was lost.

2.3 Constraint Dose to Workers

In order to ensure an adequate level of protection for each worker, as a limiting condition the process of optimization of radiological protection has adopted the value of 10 mSv per year. It is a generic restriction level of effective dose, for any source or facility associated with the practices developed in the Radiopharmaceutical Facility [3].

3 Results and Discussion

The data presented in Table 1 were derived from examinations of the individual monitoring records of the Radiation Protection Office of IPEN-CNEN/SP.

Some important indicators for individual dose distribution data used were determined in the evaluation of occupational exposure to radiation. These indicators were analyzed to identify and to correlate with the parameters that have impacted on the radiation dose of the Radiopharmaceutical workforce, such as:

- Number of monitored workers
- Total number of workers with measurable dose
- Collective effective dose
- Average measurable doses
- Average annual effective dose

The number of records for radiation monitored individuals represents the size of the population of Radiopharmaceutical Facility workers, which is 100% of their workforce. The workforce composition includes regular workers of facility, administrative persons, students and workers contracted to carry out specific tasks.

In 2011, 205 workers were monitored for external and internal exposure. This number is an indication of the size of the individual monitoring program, but it is not necessarily an indicator of the size of the exposed population. This is due to the conservative practice of providing monitoring for the total workforce. For this reason, the number of measurably exposed workers is more representative than the workforce exposed.

Internal Dose Assessment

The assessment of doses due to internal contamination was performed by *in vivo* measurements, using body counter or organ counter (thyroid).

From a total number of 205 monitored workers, 5 of them were identified as receiving a measurable intake of radioactive material in 2011. The committed effective doses ranged from 0.39 to 1.77 mSv and it was associated to an incident with iodine-131, occurred in August 2011.

The internal dose contribution is very small if compared with external dose. A little emphasis was given, mainly because there was not significant dose or some contribution to the effective dose observed over past years.

Table 1 shows the individual dose distribution, number of workers by dose range, collective dose, and average effective dose of Radiopharmaceutical Facility workers during the year of 2011.

According to dose distribution data, as shown in Table 1, 73% of the workers received doses below or equal to the recording level (0.2 mSv/month) therefore, zero dose; approximately 27% of the workers received measurable doses and about 9.7% of this group, received doses that required investigation. This last group was subject of work shift in order to keep individual doses as low as possible.

Table 1. Individual dose distribution, number of monitored workers, collective and average effective doses in the radiopharmaceutical facility during 2011

Dose range	Number of workers
$E \leq 2.4$mSv*	149
$2.4 < E \leq 5.0$ mSv	28
$5.0 < E \leq 10.0$ mSv	18
$10.0 < E \leq 15.0$ mSv	09
$15.0 < E \leq 20{,}0$ mSv	01
$20.0 < E \leq 50.0$ mSv	00
$E > 50$ mSv	00
Total of workers monitored	**205**
Collective dose (S=person.mSv)	600.99
Average effective dose (mSv)	2.93 ± 2.67
Measurable collective dose (S=person.mSv)	337.77
Total of workers with measurable dose	56
Average measurable dose (mSv)	6.03±3.40

*The value 2.4 mSv is resulting of addition of the monthly recording level, over 12 months

On the basis of the reported data, the measurably exposed workers in 2011 received annual doses ranging from 2.53 to 15.02 mSv. The group that received doses above the investigation level, ranging from 6.43 to 15.02 mSv, represents about 9.8% of the total number of monitored workers.

Following the trends from the last two decade, the level of individual average effective dose in 2011 showed a decrease of about 23% in comparison with the first year (1991) and the collective dose showed an increase of about a factor of 3. However, it is observed an increasing number of monitored workers by a factor of 4 between the first year (1991) and the last year of evaluation (2011).

The number of workers involved in radioisotope production around the world has increased, reflecting the growing use of radioisotope in both industry and medicine. However, the reported doses may vary from country to country as well as the

percentage of measurably exposed workers. This variation may be explained by many factors, including the way data are recorded in the national database, the mixing of doses related to exposed workers and non-exposed workers in the database, and the protective measures implemented by each country. These factors may affect the validity of comparisons between reported doses [6].

4 Conclusion

The main source of occupational exposure in radiopharmaceutical facility came from external irradiation. Although internal exposure has been evaluated, its contribution in the total dose was not significant.

The trends in occupational exposure observed in the last two decade and compared with the occupational doses in 2011, for the same practice, have shown that the average annual effective dose has remained constant approximately at 3.0 mSv and the average annual effective dose to measurably exposed workers decrease by 25% over the period studied.

The estimated levels of occupational exposure data for Radiopharmaceutical Facility has provided a reliable basis for the radiation protection system, established by the Radiation Protection Office team of the facility.

References

1. Sanches M.P.; Carneiro, J.C.G.G; Sordi, G. M.A.A. Social-demographic profile and dose evaluation of the radiopharmaceutical facility workers Int. J. Low Radiation, Vol. 7, No. 6, 2010 467, Inderscience Enterprises Ltd. (2010)
2. Carneiro, J. C. G. G., Sanches M.P., Rodrigues, D. L., Sordi, G. M. A. A. Occupational Exposure to Ionizing Radiation Associated with the Production of Radioisotopes. RADIO 2011 (2011)
3. Sanches, M.P., Carneiro, J. C. G. G., Rodrigues, D. L Assessment of Occupational Dose Records in a Radiopharmaceutical Facility. IRPA13 (2012)
4. International Atomic Energy Agency, IAEA. Safety Standards Series. Occupational Radiation Protection, Safety Guide, No. RS-G-1.1 (1999)
5. COMISSÃO NACIONAL DE ENERGIA NUCLEAR. Diretrizes Básicas de Proteção Radiológica CNEN-NN-3.01, (2005)
6. UNITED NATIONS. United Nations Scientific Committee on the Effects of Atomic Radiation, Sources and Effects of Ionizing Radiation, UNSCEAR 2008, Vol. I, Annex B Exposure of the Public and Workers from Various Sources of Radiation. United Nations, New York (2010)