

Dose distribution behaviour of the IPEN-CNEN/Brazil workers

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Abstract. The Instituto de Pesquisas Energéticas e Nucleares, IPEN, in Brazil has a major role in several fields of the nuclear activity, such as radiation and radioisotope applications, nuclear research reactor, testing materials and fuel cycle and radiological protection and dosimetry. The goal of this paper is to present the dose distribution behaviour of occupational radiation exposures of the monitored workers at IPEN during the years 2000 to 2007. This study is based on the dose registry data, obtained by Thermoluminescent Dosimetry to the whole body and acquired by Thermoluminescent Dosimetry Laboratory of the IPEN. The TLDs are usually positioned on the trunk between the waist and shoulder that is the part of the body with the highest exposure rate. In this study the average of 740 monitored workers over the years, meaning 100% of the participants, was considered. The results show that the values of effective dose obtained are in reasonable agreement with national regulations. The average annual effective dose in the period considered, was 3.52 ± 0.48 mSv with a maximum value of 23.31 mSv in 2001. The average and maximum values of the effective doses represent approximately 17.6% and 116.6% of the annual effective radiation dose limit, according to the recommendation of the International Commission on Radiological Protection. The overall distribution allowed the comparison of all doses reported and did not exceed the effective dose of 20 mSv per year, average over defined 5 year period. In this time period the effective dose did not also exceed 50 mSv in any single year.

KEYWORDS: *effective dose, thermoluminescent dosimeter, occupational radiation exposures.*

1. Introduction

The Instituto de Pesquisas Energéticas e Nucleares, IPEN-CNEN/SP in Brazil has a major role in several fields of the nuclear activity, such as radiation and radioisotope applications, nuclear research reactor, testing materials and fuel cycle and radiological protection and dosimetry.

Occupational exposure to radiation can occur as a result of these various human activities and it is recognized that radiation protection is only one component that must be addressed to protect the overall health and safety of the worker. In this sense, a monitoring programme for all IPEN workers, due to the occupational exposures, has been well established by the Radiation Protection Service of the IPEN.

The IPEN's Radioprotection Service, establishes comprehensive and integrated programs for the protection of workers from hazards in the workplace. The basic IPEN standards are radiation dose limits, which establish maximum permissible doses to workers and members of the public. In addition to the requirement that radiation doses not exceed the limits, all facilities are required to maintain exposures as low as reasonably achievable (ALARA) [1].

The principal focus of this study is to assess radiation doses from external exposure by workers using Thermoluminescence Dosimetry. The goal of this paper is to present the dose distribution behaviour of occupational radiation exposures of the monitored workers at IPEN during the years 2000 to 2007.

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This study is based on the dose register data, obtained by Thermoluminescent Dosimetry to the whole body and acquired by Thermoluminescent Dosimetry Laboratory of the IPEN.

In general, the dosimetry service provides the TL dosimeters, as well carry out its calibration and reading in terms of external dose. The maximum acceptable value for lower detection limit for external dosimetry is 0.20 mGy according to national regulations [2,3].

2. Methodology for occupational external radiation dose records

An individual dose record for radiation workers are kept up to date and are an essential part of the individual monitoring process. In this sense, the external doses were derived from the examinations of the individual monitoring records during the years 2000 to 2007. An average 740 workers were monitored by TLD. The TLDs are usually positioned on the trunk of individual, between the waist and shoulder that is the part of the body with the highest exposure rate.

In practice, for individual monitoring of external exposure, the measured doses are usually entered directly into the records. The minimum level of detection should then be used as the recording level, i.e. results below that level of should be recorded as zero. However, the record level considered in this study was 0.20 mSv per month [3, 4,5].

Several indicators were identified from the database to evaluate the occupational radiation exposures received at IPEN facilities. In addition, the key indicators are analyzed to identify and correlate parameters having an impact on external radiation dose at IPEN. The key indicators for the data analysis of aggregate data are number of records for monitored individuals and individuals with measurable dose, collective dose, average measurable dose, and dose distribution. Data analysis of individual dose has included an examination of doses exceeding CNEN regulatory limits, 20 mSv [3].

The records number for monitored individuals represents the size of the IPEN workforce, selected according to monitoring programme. This individual selection is determined from the number of monitoring records submitted by each site.

3. Results and discussion

The number of records for monitored individuals is an indication of the size of a monitoring programme, but it is not necessarily an indicator of the size of the exposed workforce. It is a conservative practice at some IPEN facilities of providing radiation dose monitoring to individuals for reasons other than the potential for exposure to radiation exceeding the monitoring thresholds. Many individuals are monitored for reasons such as security, administrative convenience, and legal liability.

Some sites offer monitoring for any individual who requests monitoring, independent of the risk potential exposure. For this reason, the number of records for workers who receive a measurable dose best represents the exposed workforce. The number of individuals with measurable dose includes any individuals with reported effective dose greater than zero.

Exposure data are commonly analyzed in terms of dose intervals to the dose distribution among the worker population. The Table 1 shows the number of individuals in each of 6 different dose ranges. The number of individuals receiving doses above 5 mSv is included to show the number of individuals with doses above the monitoring threshold specified in national regulations [3].

The total number of workers monitored for radiation dose, the number of individuals with measurable dose, and the relative percentages for the past eight years are presented in Table 1.

Table 1: Range doses from external exposure of the IPEN workforce monitored during the years 2000–2007.

Range doses from external exposure	IPEN workforce monitored							
	2000	2001	2002	2003	2004	2005	2006	2007
> 50 mSv	0	0	0	0	0	0	0	0
50 < H _p < 20 mSv	3	3	0	1	1	1	0	2
15 < H _p < 20 mSv	3	5	5	2	2	2	0	5
10 < H _p < 15 mSv	7	5	17	6	16	12	14	7
5 < H _p < 10 mSv	21	18	105	26	15	23	22	22
< Register Level	610	689	579	697	679	713	780	805
Total number of workers monitored	644	720	706	732	713	751	816	841
Relative percentage with measurable dose, %	5.3	4.4	18.0	4.8	4.8	5.1	4.4	4.3

Table 1 shows similar numbers of individuals monitored during the years 2000 to 2007 for dose intervals considered, except for the 5–10 mSv range in 2002. Ninety-five percent in average of the individuals had doses lower than 5 mSv. It can be seen also that the collective dose have no significant variation in this period. For the first time, there is no individual that received an effective dose above 50 mSv.

Over the past eight years, the percentage of individuals monitored for radiation exposure has remained within 4% with measurable dose of the eight-year average; only in 2002 the percentage of monitored individuals was within 18% where a number of repairs and improvements were made.

The radiological protection standard recommends a 20 mSv for effective dose averaged over defined 5 year periods [3,5]. The number of individuals receiving doses in excess of the 20 mSv is a measure of the effectiveness of IPEN's radiation protection program. As shown in Table 1, there was in average one individual who received an effective dose above 20 mSv during 2000-2007.

The behaviour distribution of effective dose and collective dose at radiopharmaceutical center during the years 2000 to 2007 is illustrated in the Table 2. The collective dose at radiopharmaceutical center exhibited an upward trend for the year 2006 and 2007 and it also shown in Table 2. The dose values obtained during 2005 to 2006 showed an increased of 19.3% and 8.9% in 2006 to 2007.

Radiopharmaceutical center had the first highest collective dose, and although the collective dose decreased from 2004 to 2005, it remained well above the value obtained for 2004. The increased on collective dose in 2006 to 2007 can be attributed in the isotope production work mainly in package activities performed.

Table 2: Distribution of collective dose and effective dose at Radiopharmaceutical center, 2000 –2007.

Radiopharmaceutical Center	2000	2001	2002	2003	2004	2005	2006	2007
Collective dose (person-mSv)	540.93	551.33	446.69	519.90	442.13	411.16	490.59	534.46
Average dose (mSv)	4.16	3.75	2.83	3.02	3.98	3.43	3.45	3.38
σ (mSv)	6.71	2.99	2.22	2.14	3.73	3.67	3.18	3.42
Number of monitored individuals	130	147	158	172	111	120	142	158
Number of individuals up average dose	29	32	37	42	29	30	37	38
Number of individuals down register level	86	98	117	102	73	81	88	102
Number of individuals up investigation level (6.0 mSv/year)	23	22	12	14	24	20	24	16
Number of individuals up operational value (20.0 mSv/year)	3	1	0	0	0	0	0	1
% up of investigation value	17.7	15	7.6	8.1	21.6	16.7	16.9	10.1

4. Conclusion

As well as the need to show compliance with dose limits, records retention is important for four additional reasons: provide data for analysis of dose distributions; to evaluate exposure trends which may take into account collective dose; to optimize the effectiveness of monitoring procedures and programmes; and to provide data for epidemiological studies.

Over the past 8 years, the collective dose and exposed workforce size have remained at fairly stable levels. For the past two years, there has been an increasing trend in almost all of the indicators used in the analysis of occupational exposure. Most of this increasing has been attributed to the isotope production activities.

The detailed nature of the data available has made it possible to investigate distribution and trends in data, and to identify and correlate parameters having an effect on occupational radiation exposure at IPEN facilities.

The IPEN facilities that have contributed significantly to the increasing collective dose are the radiopharmaceutical center and the cyclotron.

The average annual effective dose in the period considered, was 3.52 ± 0.48 mSv with a maximum value of 23.31 mSv in 2001. The average and maximum values of the effective doses represent approximately 17.6% and 116.6% of the annual effective radiation dose limit, according to the recommendation of the International Commission on Radiological Protection.

There were no exposures in excess of 50 mSv in any single year. The overall statistics allow the comparison of all doses reported and not exceed the effective dose of 20 mSv per year, averaged over defined 5 year periods.

The monitoring data relative to the external doses were stripped from the individual data records and the results showed that the values of effective dose obtained are in reasonable agreement with national regulations.

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