

Assessment of Occupational Dose Records in a Radiopharmaceutical Facility

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INTRODUCTION

The Instituto de Pesquisas Energéticas e Nucleares, IPEN - CNEN/SP, is the major center, in Brazil and it is responsible for the radioisotope and radiopharmaceutical production as well it's processing labeling and distribution, mainly for medicine uses.

The aim of this work is to carry out a retrospective study of occupational doses over the last 20 years (1991-2010) from Brazilian Radiopharmaceutical Production Facility.

MATERIALS AND METHODS

- 2,455 individual records were evaluated and the dose distribution was shared in six doses ranges: 0-2.4; >2.4-5; >5-10; >10-15; >15-20; >20 (mSv). 100% of the workforce was monitored for external and internal irradiation For external irradiation by Thermoluminescent Dosimeters, TLD (CaSO₄:Dy) and for internal contamination by direct measurements (body counter).

Variables considered:

- The record level : 2.4 mSv/year (Brazilian regulatory authority).
- Measurable dose: annual dose > 2.4 mSv;
- A dose level of 10 mSv was chosen in accordance to the mid-value of the annual dose limit. The annual dose level < 10 mSv was considered low to moderate exposures, and ≥10 mSv value was considered dose high, under investigation.
- Only the $H_p(10)$, which estimates the effective dose, was included in the analysis.
- Results of internal exposure was not included in this work.

RESULTS AND DISCUSSION

- Trends of occupational dose due to Brazilian Radiopharmaceutical Production, during the years 1991-2010, summarized in Tables 1 and 2.

Table 1. Annual effective dose range distribution (1991-2010)

Dose range (mSv)	Monitoring period (Year)									
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
0 < E ≤ 2.40	35	29	24	30	53	51	68	76	77	88
2.40 < E ≤ 5.0	10	13	22	19	08	08	17	07	11	15
5.0 < E ≤ 10.0	05	07	10	03	09	07	06	12	14	17
10.0 < E ≤ 15.0	01	06	02	04	04	05	07	10	09	07
15.0 < E ≤ 20.0	01	01	04	01	03	03	03	06	03	01
E > 20	01	02	02	02	02	10	04	01	01	03
Number of monitored workers	53	58	64	59	79	84	105	112	115	131
Dose range (mSv)	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0 < E ≤ 2.40	100	118	100	73	81	88	102	133	127	159
2.40 < E ≤ 5.0	22	22	46	12	12	26	29	24	39	30
5.0 < E ≤ 10.0	20	17	21	13	16	16	18	16	16	16
10.0 < E ≤ 15.0	06	03	04	11	09	12	05	04	08	02
15.0 < E ≤ 20.0	00	00	00	02	02	00	03	07	00	02
E > 20 mSv	01	00	00	00	00	00	01	00	01	00
Number of monitored workers	149	160	171	111	120	142	158	184	191	209

Table 2. Distribution of occupational dose (effective and collective) to monitored workers (1991-2010)

Dose	Monitoring period (Year)									
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Number of monitored workers	53	58	64	59	79	84	105	112	115	131
Total collective dose (person.mSv)	203,33	282,24	341,45	295,60	378,70	619,90	483,4	542,35	512,03	543,33
Average effective dose (mSv)	3,84±6,04	4,87±6,51	5,34±6,03	5,01±6,98	4,79±5,64	7,38±10,23	4,60±6,38	4,84±4,74	4,45±3,95	4,15±6,68
Measurable collective dose (person.mSv)	144,93	238,40	300,85	226,60	254,00	519,60	362,6	359,95	327,23	374,74
Number of measurably exposed workers	18	29	40	29	26	33	37	36	38	43
Average measurable effective dose (mSv)	8,05±9,09	8,22±7,90	7,52±6,74	7,81±9,21	9,77±7,80	15,74±12,34	9,80±8,59	10,00±5,58	8,61±4,64	8,71±10,30
Dose	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Number of monitored workers	149	160	171	111	120	142	158	184	191	209
Total collective dose (person.mSv)	556,13	451,84	519,90	442,13	411,16	490,81	542,06	586,12	600,21	539,24
Average effective dose (mSv)	3,73±2,98	2,82±2,21	3,04±2,14	3,98±3,73	3,43±3,67	3,45±3,19	3,43±3,49	3,18±3,71	3,14±2,86	2,58±2,59
Measurable collective dose (person.mSv)	316,13	229,38	329,39	302,35	292,57	341,35	358,7	371,48	355,79	285,99
Number of measurably exposed workers	49	42	71	38	39	54	56	51	64	50
Average measurable effective dose (mSv)	6,45±4,01	5,46±2,86	4,64±2,46	7,96±4,06	7,50±4,03	6,32±3,58	6,40±4,47	7,28±5,07	5,56±3,85	5,72±3,66

- 65.66% of the workforce monitored received doses lower than 2.4 mSv/y (Table 1) i.e., below the record level (dose zero);
- 34.32% of total number of monitored workers received measurable dose, being 26.52% (2.4<E<10.0) mSv/y and 8.0% received doses ≥10.0 mSv/y.
- The highest recorded annual effective dose was 66.94 mSv in 2000, received by one worker involved in the hot cell maintenance task.
- The average annual effective dose of all monitored workers ranged from (2.58-7.38) mSv over a 20-y period with an mean value of 3.80 mSv (Table 2).
- The average annual effective dose of measurably exposed workers ranging of 4.64 - 15.74 mSv.
- The ratio of collective effective dose between first year (1991) and the last year (2010) increased about a factor 2.6 probably due the increasing of radioisotope production.
- The results showed a variation in the average annual effective dose among the different occupational groups: 1.89mSv/y (research, quality control procedures, administrative staff), 4.82mSv/y (production, labeling and distribution) and 16.41mSv/y (maintenance and packing tasks).

CONCLUSIONS

- The evaluation of trends in occupational exposure arising from radiopharmaceutical production facility showed that 92% of workers received an annual dose lower than 10.0 mSv. Although the fraction of the highly exposed workers is small, there was a significant impact on the collective dose and its contribution was high about 30%. Highly exposed workers tended to concentrate in a few identified occupational groups related with maintenance and packing tasks (≥10 mSv).
- The number of exposed workers, the annual effective dose ≥10.0 mSv, and the corresponding collective effective dose may be a good indicator of the institutional radiation safety practices, since are strongly correlated to the total collective effective dose.
- Considering the dose constraint of 10.0 mSv, attributed to exposed occupational groups, the average collective effective dose was estimated to be about 157.0 person.mSv.