

# Trends in Occupational Exposure at Different Practices in a Nuclear Facility

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## INTRODUCTION

The Nuclear and Energy Research Institute, IPEN is located in São Paulo city-Brazil, with the main purpose of doing research and development in the fields of nuclear energy and its applications.

IPEN has a rigorous program of radiological control and nuclear safety for the activities related to nuclear and radiological aspects, including personal and environmental monitoring and radiological emergency assistance, in compliance with the regulatory requirements.

The present work focuses mainly the IPEN facilities dealing with radioisotopes production: Radiopharmacy, Cyclotron Accelerators and IEA-R1 Research Reactor, during the last decade.

## OBJECTIVES

- Information about the level of occupational exposure from different practices carried out at IPEN during the years 2001 to 2010.
- Assessment of the contribution of the considered facilities on the IPEN environmental background radiation and the impact on the effective dose.

## METHODS

### Occupational Exposure

- Assessment derived from the radioprotection service data base of individual dose records and analysis of trends of annual effective dose (dose range), numbers of monitored workers and percentage of measurably exposed workers.
- 100% of the workforce was monitored for external and internal irradiation.
- **External Irradiation:** routine individual monitoring of workers by Thermoluminescent Dosimetry (TLD).
- **Internal Irradiation:** direct measurements (whole body).

Previous routine monitoring showed that external radiation exposure is more significant than internal radiation exposure:

→ internal exposures not included in the reported statistics.

### Environmental Background Radiation

- **External gamma radiation:** 15 monitoring stations using Thermoluminescent Dosimeters - five of them at points of maximum predicted ground-level concentration, and the ten remaining ones in locations with no direct influence from the IPEN facilities.
- **BG** determined considering the annual mean value for the last decade.
- **Annual effective** dose estimated according to national and international radiological protection standards.

## RESULTS AND DISCUSSION

Occupational Exposure - Doses associated with specific practices for the decade 2001 to 2010 summarized in Tables 1, 2 and 3.

**Table 1. Trends in total numbers of monitored Radiopharmacy workforce/year and number of workers aggregated in each dose range.**

Dose Range (mSv.y <sup>-1</sup> )	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0 – 2.4	100	118	100	73	81	88	102	133	127	159
>2.4 – 5	22	22	46	12	12	26	29	24	39	30
>5 – 10	20	17	21	13	16	16	18	16	16	16
>10 – 15	06	03	04	11	09	12	05	04	08	02
>15 – 20	00	00	00	02	02	00	03	07	00	02
> 20	01	00	00	00	00	00	01	00	01	00
<b>Total of monitored workers (1595)</b>	<b>149</b>	<b>160</b>	<b>171</b>	<b>111</b>	<b>120</b>	<b>142</b>	<b>158</b>	<b>184</b>	<b>191</b>	<b>209</b>

**Table 2. Trends in total numbers of monitored Cyclotrons workforce/year and number of workers aggregated in each dose range.**

Dose Range (mSv.y <sup>-1</sup> )	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0 – 2.4	8	13	9	5	6	11	4	8	6	10
>2.4 – 5	2	3	6	6	4	4	5	5	10	4
>5 – 10	0	0	2	2	6	5	4	4	6	5
>10 – 15	0	2	2	5	3	2	2	2	1	0
>15 – 20	2	0	1	0	0	0	2	1	1	1
> 20	0	0	0	0	1	0	1	0	0	0
<b>Total of monitored workers (192)</b>	<b>12</b>	<b>18</b>	<b>20</b>	<b>18</b>	<b>20</b>	<b>22</b>	<b>18</b>	<b>20</b>	<b>24</b>	<b>20</b>

**Table 3. Trends in total numbers of monitored IEA-R1 Research Reactor workforce/year and number of workers aggregated in each dose range.**

Dose Range (mSv.y <sup>-1</sup> )	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0 – 2.4	-	136	139	157	160	186	153	116	166	189
>2.4 – 5	-	0	0	0	0	0	0	62	7	0
>5 – 10	-	0	0	0	0	0	0	0	0	0
>10 – 15	-	0	0	0	0	0	0	0	0	0
>15 – 20	-	0	0	0	0	0	0	0	0	0
> 20	-	0	0	1	0	0	0	0	0	0
<b>Total of monitored workers (1472)</b>	<b>-</b>	<b>136</b>	<b>139</b>	<b>158</b>	<b>160</b>	<b>186</b>	<b>153</b>	<b>178</b>	<b>173</b>	<b>189</b>

**Table 1:**

68% of a total of 1595 individual records received dose zero (health zero risk), below the Brazilian recording level (RL) of 2.4 mSv.y<sup>-1</sup>. Considering the ICRP RL of 5 mSv.y<sup>-1</sup>, about 84% of them received dose zero.

1.3% of monitored workers, mainly involved in the packing-task group received doses higher than 15.0 mSv, which required further investigation.

**Table 2:**

42% of a total of 192 individual records received dose zero (health zero risk), below the Brazilian recording level (RL) of 2.4 mSv.y<sup>-1</sup>. Considering the ICRP RL of 5 mSv.y<sup>-1</sup>, about 67% of them received dose zero.

5.2% of monitored workers, mainly involved with the maintenance in cyclotron targets system received doses higher than 15.0 mSv.

**Table 3:**

95% of a total of 1472 individual records received dose zero (health zero risk), below the Brazilian recording level (RL) of 2.4 mSv.y<sup>-1</sup>. Considering the ICRP RL of 5 mSv.y<sup>-1</sup>, 100% of them received dose zero.

Less than 0.1 % of monitored workers received doses higher than 15.0 mSv.

### Environmental Background Radiation

➤ Average annual background effective dose during the 2001-2010 decade : (0.9 ± 0.2) mSv.y<sup>-1</sup>.

➤ During the 2001-2010 decade, the highest average annual effective dose of (2.4 ± 0.8) mSv.y<sup>-1</sup> was obtained for two monitoring stations of maximum predicted ground-level concentration, as consequence of handling radioactive waste and normal operation of the cyclotrons.

## CONCLUSIONS

- ✓ Individual radiation exposures during the execution of some specific jobs are found to be quite high. The evolution of doses due to normal operation and maintenance at cyclotron, radioisotope production and reactor with elevated levels of exposure can be the consequence of many factors. However, the trend of doses observed over the decade 2001-2010 shows that the majority of monitored workers received low doses in compliance with regulatory requirements.
- ✓ The data indicate that improvements should be continuously reinforced, as reduction in the number of tasks performed by workers, implementation of ALARA programs and better job preparation.
- ✓ Only 4% of the monitored workers exceeded 5 mSv.
- ✓ No worker exceeded a total effective dose of 50 mSv in a single year.

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