2007 International Nuclear Atlantic Conference - INAC 2007
Santos, SP, Brazil, September 30 to October 5, 2007
ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR - ABEN
ISBN: 978-85-99141-02-1

A SURVEY OF THE WORKER DOSE RATE AT IPEN-CNEN/SP NUCLEAR FUEL CYCLE FACILITIES

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ABSTRACT

The radiological protection system recommended by the International Commission on Radiological Protection (ICRP) established three basic principles, namely justification, optimization and dose limitation. The ICRP and the standard CNEN.NN.3.01, of the Comissão Nacional de Energia Nuclear request that these general principles be aplied in the control of a practice like the fuel element fabrication.The doses which the workers are submitted to should be in accordance with ALARA conditions “as low as reasonably achievable”.This work discusses the doses received by workers and also present in their working place, in the practice of the nuclear fuel fabrication.One of the production lines for the nuclear fuel is the production of enriched uranium hexafluoride and uranium tetrafluoride.In the sequence,metallic uranium is obtained, followed by the fusion with mettalic silicede, and result in the uranium silicede compost (U_3Si_2).This material is worked metallurgically for obtaining the fuel element core, known as plates.Each fuel element comprises 18 plates.The workers of the fuel element plants are monitored individually by thermoluminescent dosimeters of calcium sulphate doped with dysprosium $CaSO_4$:Dy.The survey of the doses received by the workers in within the register level,i.e, less than 0.2mSv per month.The local monitoring is carried out with MIP10 equipment,Geiger-Müller detector and alpha detector/Ludlum 2000. These two kinds of monitoring are discussed in this work.

1. INTRODUCTION

The practice of the manufacture of the fuel element comprises the basic principles of radiation protection , management and technical requirements. The practice produces liquid positive benefits for technological development and for society. Since the society benefits of the radioisotope produced in a research reactor that needs the fuel produced by practice.The system of doses limitation is applied to the workers during the development of the practice , in the different phases of the production of the fuel element namely:

Phase a. Enrichment of 19.75% uranium hexafluoride UF_6 to uranium tetrafluoride UF_4;
Phase b. metallic uranium production degree with the reaction:the reaction

$$UF_4 + 2\,Mg^0 \rightarrow U^0 + 2\,MgF_2 \quad (1)$$

and uranium silicede as a result of the reaction

$$3U^0 + 2\,Si^0 \rightarrow U_3Si_2 \quad (2)$$

Phase c. Powder U_3Si_2 processing up to the briquets production (dust compacting $U_3Si_2 + Al^0$) ;
Phase d. Mecanic and metallurgic processing of the briquets up to the fuel element plate.

The workers, IOE are in areas classified as controlled areas where there is potencial risk in the following phases a,b,c,and supervised areas, phase d.

All workers are individually monitored for control of the external and internal radiation.[1,3]. The control for external radiation is carried out through thermoluminescent dosemeters type calcium sulphate dopat with Dysprosium. The dosimeters are changed monthly.

The control of the intake is carried out in-vitro, with the method of analysis for alpha espectrometry. The annual limits of dose, for administrative purpose of control, established in the country by the Comissão de Energia Nuclear and at international level by the IAEA establish an effective dose of 20 mSv per year, averaged over five consecutive years, since 50 mSv does not exceed in any single year [1,4].

In this work, the survey of a period of 11 years of the dose will be evidenced effective that the workers of these phases present the result of the dose rates of the workstations of longer permanence, evidencing the concept ALARA of the doses to be as low as feasible is present in the practice developed.

2. METHODS

The practice of the fuel element fabrication used as raw material enriched uranium.This material emmits alpha, beta particles and foton (X, gamma) [2]. The individual exposed occupacional uses dosimetry thermoluminescent type $CaSO_4$:Dy to detect the external radiation field which he is submmited to in his work. A survey of effective dose since 1995 to 2005 was carried out, showing 90% the workers had taken dose below the register level. For the 10% who had a dose above the register level, the collective dose was calculated for the group of workers from each workplace. As the register level is 0.2 mSv/month in Brazil, only the monthly external radiation doses exceeding this value were considered. To each phase indicated by the letters a,b_1,b_2,c,d there is a correspondent group of workers. Using a Geiger-Müller detector the workplace dose was determineted. The workers are especified each phase. Detector Geiger Müller was used for monitoring the workplace and MIP10 was used in direct contamination the workers and Ludlum made the contamination on smears carried out.

2.1. Controlled and Supervised Areas

In controlled areas the chemical and metallurgic process of fissil uranium material there is a potencial risk for handling this material in gas,liquid and powder. The phases developed in these controlled areas are identified as a,b_1,b_2, c, whereas d phase is identified as supervised where the fuel element plate is made.

The facilities where the fuel element processing is performed are shown and also the highest doses value for these workplaces. The values were showed by a Geiger Müller detector for dose rate , alpha Ludlum type for smears observation, with results expressed in Bq/cm^2 . The smears are used for floor monitoring near the equipment. The MIP 10 detector was used for reading the external contamination of the workplace.

The facility correspondent to the controlled area known as phase a, is showed in figure 1. Only one space used is seen. The Arabic numbers used in figure 1 represent the equipment in phase a.

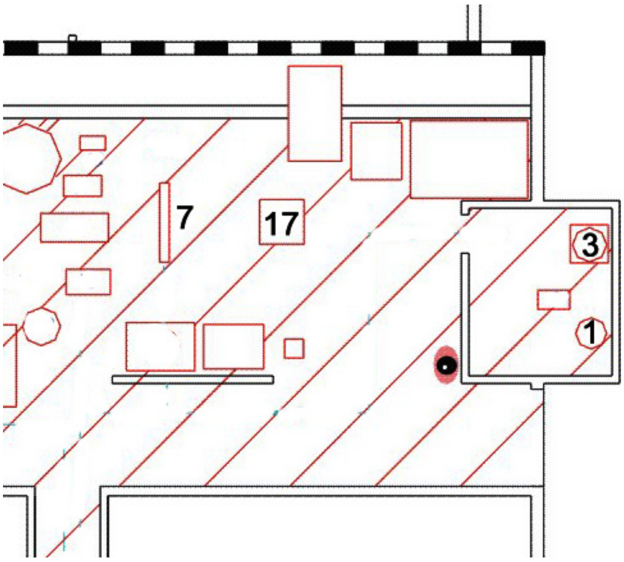


Figure 1. Phase a Enrichment uranium UF_6 to UF_4.

Table 1 represents the doses rates in the workplace in phase a and the results of the smears carried out in the floor, near the equipment, are represented in figure 1 above numbers 1,3,7,and 17.

Table 1. Dose rate and superficial contamination values in phase a

Equipment	Dose rate µSv/h	Contamination Bq/cm^2
1.Vertical furnace UF_6 cylinder	0.78	0.04
3. UF_6 bladder	0.62	0.04
7.Hydrolyse Reactor UF_6	0.7	0.06
17 Procution Reactor UF_4	2.0	0.19

The next facility in figure 2, only the equipment utilized are in evidence, indicated by the Arabic numbers, but in figure 3 and 4 the equipment utilized are indicated by letters.

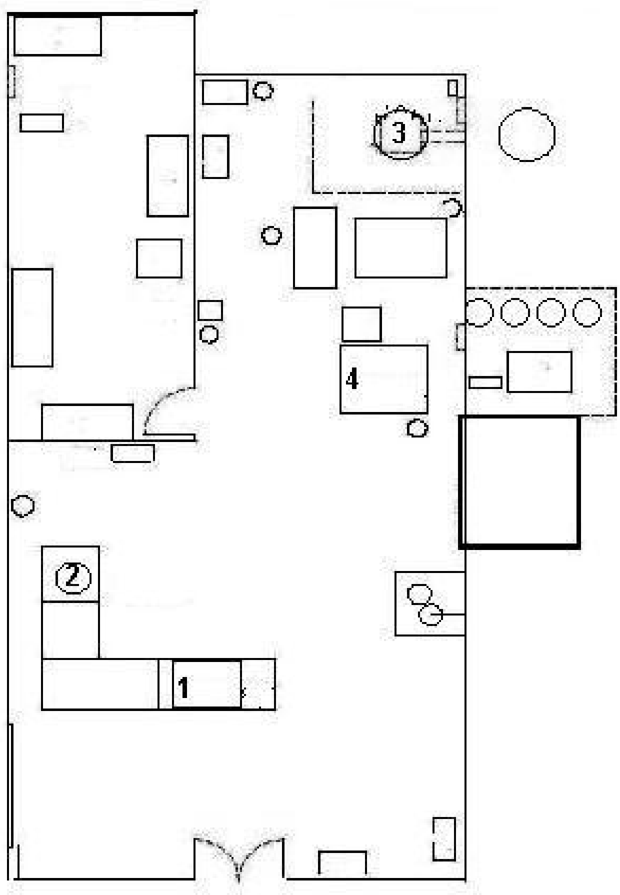
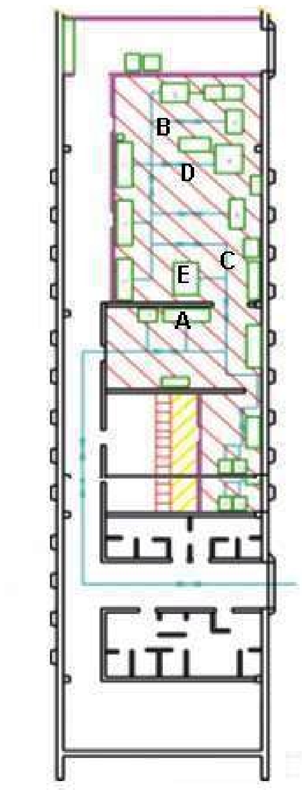


Figure 2. Phase b U^0 to U_3Si_2 Production

Table 2. Dose rate and superficial contamination values in phase b.

Equipment	Dose rate µSv/h	Bq/cm^2
1- Mix UF_4 , Mg^0	0.4	0.06
2- Reduction Reactor UF_4 , Mg^0	0.8	0.09
3- Furnace UF_4 , Mg^0	0.7	0.05
4-Induction Furnace $U^0 + Si^0 0$	.4	0.11



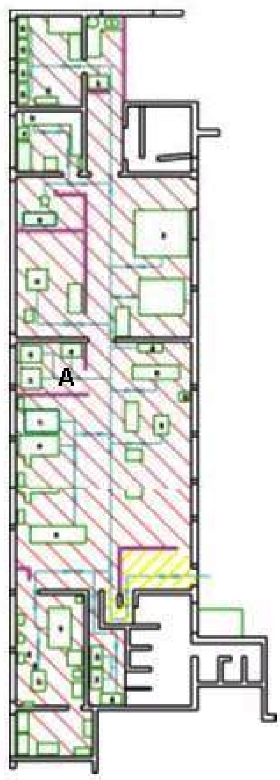


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Figure 3. Represents phase c . **Figure 4. Represents phase d**

Table 3. Dose rate and superficial contamination values in phase c

Equipment	Dose rate µSv/h	Superficial contamination Bq/cm^2
A briquet place control	23.40	0.09
B press material place	0.32	0.28
C press	0.26	0.11
D furnace place	0.33	0.18
E Glove-box U_3S_{i2}	1.2	0.26

Table 4. Dose rate and superficial contamination values in phase d

Equipment	Dose rate µSv/h	Superficial contamination Bq/cm^2
A fuel element storage	0.57	0.05

3. COLLECTIVE EFFECTIVE DOSES

The collective effective doses survey for workers of the fuel element production facilities are the individual dose that showed monthly higher values than the register individual levels.

Table 5. Collective effective dose of the workers

Year	Collective effective dose mSv.man/year Phase *a	Collective effective dose mSv.man/year Phase **b_1, b_2	Collective effective dose mSv.man/year Phase ***c	Collective effective dose mSv.man/year Phase ****d
1995	2.9	0.0	0.0	0.0
1996	1.7	0.0	0.0	0.0
1997	0.9	0.0	0.0	0.3
1998	5.2	0.9	0.9	1.5
1999	5.8	0.4	0.0	3.5
2000	1.2	0.2	0.2	0.0
2001	0.0	0.0	0.0	1.8
2002	0.0	0.0	0.0	0.0
2003	0.0	0.2	0.4	0.0
2004	0.0	0.0	0.0	0.0
2005	0.0	0.6	0.5	0.0

*Phase a Enrichment uranium UF_6 up to UF_4 production
**Phase b_1,b_2 U^0 and U_3Si_2 production
***Phase c Briquet U_3Si_2 production
****Phase d plate fuel element production

4. CONCLUSIONS

As exposed in table 5, phase a of the fuel element production process development was observed to present collective dose in the period 1995 to 2000. In the years 1998 and 1999, the workers collective dose value was higher than the individual register level of 5 mSv/year. All the phases evidenced collective dose in 1998, so there was continuous production in the facilities. The dose rates where the workers spend longer periods during each phase, showed values below the individual register level, with values as low as feasible inside nuclear fuel processing facilities.

ACKNOWLEDGMENTS

The authors thanks to Davilson Gomes da Silva for drawing the figures.

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