Radiological Protection Performance in Radiopharmaceutical Facility

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Abstract. The Radiopharmaceutical Facility (RF) of the IPEN-CNEN/SP has processed and handled several radionuclides and compounds, in unsealed form, in amounts that require specific procedures to avoid contamination, intake and unexpected exposures of the workers, in order to do not resulting doses over of the waited standards. The (RF) is committed to good work area management of all its potential risks, minimizing risks to the work area, and anticipating and addressing potential problems before they pose a threat to the quality of the local areas. The radiological protection team has established a radiological protection program whose purpose is to provide an adequate occupational worker protection system in agreement to national and international radiological protection standards. The main objective of this study is to correlate the unusual events occurred in the (RF), over the years, that in some way contributed with failure in the process that led to an intake and or an external exposure, or contamination in the workplace. For the analysis, the reports from the radiation protection supervisor, complemented by interviews with the workers and radiation protection officers were considered. Several indicators were identified from the analyses of data that can be used to evaluate the occupational radiation exposures received at (RF) facility. In addition, the radiological protection measures adopted, the lessons learned to prevent new events, of the same nature, and it benefits that include enhancing the workplace environment and reducing the number of incidents were implemented and discussed in this paper. The detailed nature of the data available allowed investigating the distribution and trends of the data.

KEYWORDS: radiological protection, potential risks, unsealed sources, occupational radiation exposure

1. Introduction

The Radiopharmaceutical Facility, RF, of the "Instituto de Pesquisas Energéticas e Nucleares", IPEN, is a facility that produces and distributes all radiopharmaceuticals material in Brazil. These radiopharmaceuticals material are unsealed sources of ionizing radiation used mainly in medical diagnostic examinations and in therapeutic treatments. Actually are produced about 800 TBq of activity, becomes possible the accomplishment of more than three millions of medical procedures in the country. Since 80s years there is a growth radioisotopes productions in approximately 10% per year. When handling unsealed radioactive material, exposures may occur and the workers are potentially exposed to risks of contamination and external exposure. In addition the spread of contamination out of the laboratories can also occur from these practices. The facility has a radioprotection group which implements an adequate protection system based on radiological protection national [1] and international [2] standards. The monitoring program is part of the quality system and good manufacturing practices for radiopharmaceutical production facility based on documentations as operational procedures (POPs), work rules (WRs) and forms. In this paper are presented and discussed the unusual events that occurred during the years 2003 to 2007 and have caused to workers external contaminations and/or workplaces contaminations.

1.1 Control of Radioactive Contamination

The workers must maintain the constant care and knowledge the basic procedures to avoid and to deal with radioactive contamination [3,4]. For this reason, procedures and adequate working rules had been written. In addition, a periodic radiological protection refreshing training based on the experience of professionals, focusing on the eventual problems that arise from tasks is implemented. As a control measure to avoid the spread of contamination are used individual protection equipments, IPEs, and

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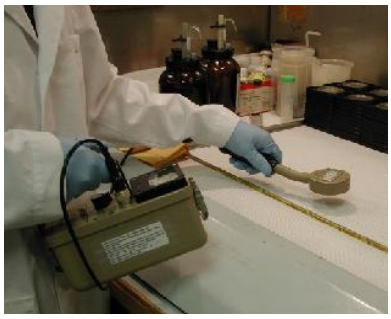
contamination monitors as shown in Fig. 1. Workers should use these equipments during their activities and when they leave the workplace, according to the quality assurance guidelines. In this case, the workers carry out both the control of yours clothing and body parts unprotected with monitors located in the workplaces exit.

Another control access measure is the use of individual magnetic badge to access the workplaces classified as a radiological area, demarcated by physical barriers and monitored for video cameras, illustrated in Fig. 1 (c).

In this sense, so that the worker to carry out its activities in a radiological area is necessary to have an authorization of facility head under the orientation of radioprotection team. Some activities required the physical presence of a radioprotection worker team.

The aim of all these measures is to ensure that the recommended dose limits for workers do not exceed. The recommended dose limits for workers is 20 mSv per year, averaged over defined periods of 5 years, and the restriction on occupational exposure of pregnant women [1].

Figure 1: Monitors of Contamination



(a) Portable contamination monitor used in radiological area.

(b) Portable contamination monitor located at the exit of radiological area

(c) Surface contamination monitor type feet and hands, located in the exit of radiological area.

2. Methodology

The data analysis considers the reports of internal occurrences prepared by the radioprotection supervisor, the records book and the interviews with workers of operation and radioprotection team. The reports of workers were compared with procedures and rules described in the quality assurance documents, POPs and WRs.

3. Results

Specific procedures are prepared in advance to ensure that the work is performed in an adequate protection, in routine situations and in adverse situations. The non-compliance with these procedures can generate unusual events at workplace.

Following are described the most relevant cases of unusual events at workplace from 2003 to 2007.

Case 1

Identification: surface area contamination (floor) and personal contamination (workers and visitors' footwear) with ^{131}I.

Number of individuals involved: 39 individuals, 14 external visitors and 25 workers.

Occurrence: A worker of the facility realized maintenance in the ^{131}I hot cell without authorization; after operational changes; a contaminated piece removed was supported in front of the hot cell floor resulting in a contaminated area. When the worker left the area with your boot contaminated, the contamination was transferred to personal shoes. This worker did not use the surface contamination monitors during maintenance task, and also do not performed self contamination survey before leaving the area (monitoring devices and the protective equipment and clothing). The consequence of this failure procedure was the spreading contamination to other points of the installation causing 39 external contaminations in personal footwear.

Protective measures adopted: monitoring of all individuals involved; footwear decontamination efforts or exchange them; interviews with the workers for contamination verbal notification responsibilities to identify the causes; proper surveys procedures for contamination points mapping; contaminant agent characterization and area decontamination procedures.

Causes: A lack of workers' knowledge of the fundamentals of radiation protection and safety; the radioprotection staff wasn't called anticipated to monitoring when performing a specific task. The authorization to work in radiological areas form did not fill out.

Solutions: Operational staff should be responsible for planning and performing work in accordance with appropriate standards, approved procedures, work instructions and any other established requirements of facility; ensuring that items, equipment and services are inspected or tested to demonstrate that they will perform as intended. In addition periodic retraining should be provided to ensure that workers have the most up to date knowledge relevant to their work, and that they do not become complacent about workplace hazards.

Case 2

Identification: surface area contamination (laboratories sinks plumbing) and personal contamination (workers' footwear) with ^{131}I.

Number of individuals involved: 2 workers.

Occurrence: A plumbing blocked with resin and leaked; workers stepping in the contamination area and had contaminated their shoes.

Protective measures adopted: area monitoring, specially of floor in proximity to the laboratories sinks; individual monitoring, monitoring for personal shoes and clothing; interdiction, notification, warning signs, and labels used to alert others to the presence of the hazard until subsequent clean up activities are completed at the site of the leak; evaluating procedures, resin sample analysis and radionuclide identification for contamination recognition; after these hazards identification, precautions be taken to assure that there is minimal chance for exposure to personnel, examples of precautions would include performing the procedure of new monitoring at the site of the leak.

Causes: The laboratory has sinks for common and contaminated materials; the pipes of these sinks are joined in a common junction. A resin was disposal in the sink for common materials; however, the resin has accumulated in the common junction. With the constant disposal of contaminated materials on the sink contaminated, the ^{131}I adsorbed in the resin that it blocked and leaked the sinks plumbing.

Solutions: to provide the separation of the pipe sinks and should be clearly designated; to make suitable treatment and storage of resins; to ensure that any work involving occupational exposure be adequately supervised and take all reasonable steps to ensure that the rules, procedures, protective measures and safety provisions be observed.

Case 3

Identification: surface area contamination (locker room) and personal contamination (workers' footwear) with ^{99}Mo.

Number of individuals involved: 2 workers.

Occurrence: self contamination survey detected shoes contamination in two workers.

Protective measures adopted: additional surveys to complement a self contamination survey of workers involved; interviews with workers for contamination verbal notification responsibilities to identify the possible causes; proper surveys procedures for contamination points mapping; contaminant agent characterization; and personal and area decontamination procedures.

Causes: the workplaces procedures established by radioprotection staff for radiological area were not followed correctly by workers and contributed to spread contamination to cleaning areas.

Solutions: to establish in writing such local rules and procedures necessary to ensure adequate levels of protection and safety for workers and others persons; provision of specific training and instructed personnel in the proper procedures for the safe use of radioactive materials; use the appropriate personal protective equipment..

Case 4

Identification: personal contamination with ^{99m}Tc.

Number of individuals involved: 1 worker.

Occurrence: worker presented external contamination after cleaning the floor in front of hoods and workbenches.

Protective measures adopted: additional survey to complement a self contamination survey of involved worker; remove gloves, remove protective clothing and wash hands thoroughly; additional survey to monitor the hands, clothing and shoes after decontamination procedure; decontamination was be carried out until the surface levels are below the appropriate limits.

Causes: during the collection of common waste in a disposal area of unsealed radioactive material a worker manipulated improperly radioactive waste containers.

Solutions: suitable storage for waste, clearly identification of kind of waste with proper labels; adequate instruction and training on protection and safety procedures and local rules.

Case 5

Identification: surface area contamination (floor) and personal contamination (shoes) with ^{67}Ga.

Number of individuals involved: 2 workers.

Occurrence: laboratory contaminated floor

Protective measures adopted: Additional survey to complement a self contamination surveys of involved workers; decontamination procedure was be carried out until the surface levels are below the appropriate limits; footwear decontamination efforts or exchange them; workers interviews for contamination verbal notification responsibilities to identify the causes; radiometric surveys for

mapping the contamination points; characterization of the contaminant agent and decontamination of the points.

Causes: a worker was handling unsealed radioactive material and while performed the task incidentally occurred a spill; this lead to contamination spreading in the workplace.

Solutions: area decontamination procedure; provision to workers adequate instruction and training on protection and safety procedures, and adequate information on the significance for protection and safety on their actions.

The causes of these unusual events are illustrated in Fig. 2 and in Fig. 3 are presented the solutions adopted to prevent or reduce the unusual events.

Figure 2: Causes of unusual events occurrences.

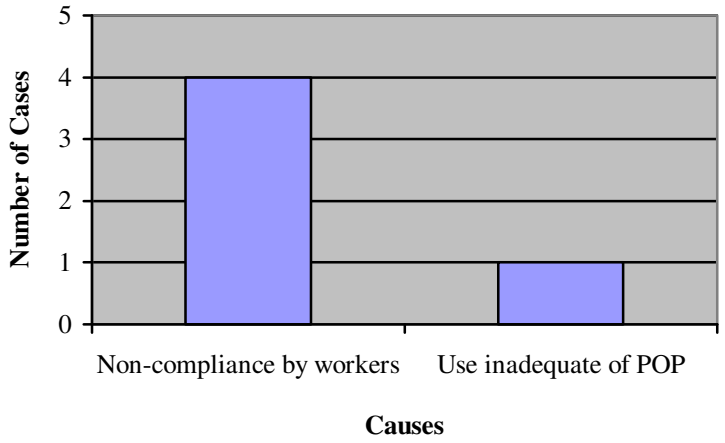
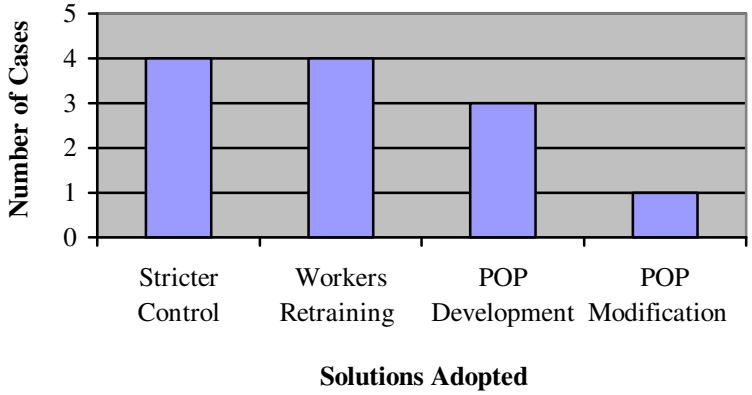


Figure 3: Solutions adopted to prevent unusual events.



4. Discussions and Conclusions

A systematic critical review of the nature and magnitude of the unusual events occurrence was made and the data analyze showed that 80% of these events are consequences of non-compliance with operating procedures and improperly knowledge by workers. This resulting gave rise in contamination of individuals and the workplace, emphasizing that in any case there was not contamination outside facility.

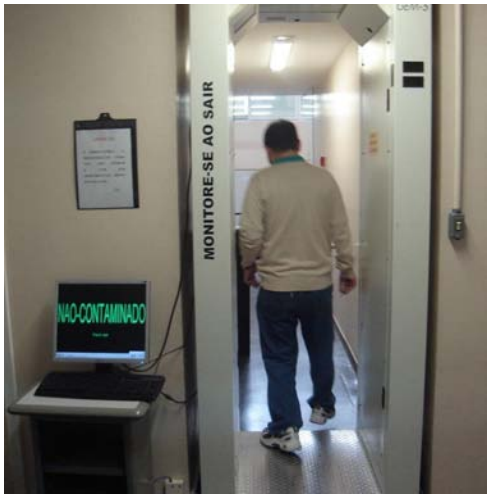
The unusual events presented in this paper don't generated doses by external and internal exposures above the recommended limits for workers.
In particular, the case 1 was the event that represents the greater involvement of individuals, at the workplace.

After the identification of initiators agents of these unusual events, the radioprotection team implemented some improvements in the workplace such as a stricter control of procedures, development of new POPs and its modification, when applicable. In addition, the retraining of the worker in safety principles and good practice in handling radioactive materials should be continuously reinforced in accordance with the difficulties encountered in development of their activities.

In Fig. 4, is illustrated a portal monitor of compulsory use in entry and exit of the workplace was installed to provide an additional control measures.

Figure 4: Portal monitor and barrier arm turnstiles.

(a) Portal monitor and magnetic badge Bi-directional Barrier Arm Turnstiles for access control system - entry.



(b) Portal monitor and magnetic badge Bi-directional Barrier Arm Turnstiles for access control system - exit.

The radioprotection group of the RF has participated efficiently over the years, through the implementation of security devices, minimizing the risks and preventing future abnormal situations in the workplace and potential external exposure. Finally, the worker is responsible to put into practice their knowledge to prevent the occurrence of new events that may generate external exposure or radioactive contamination unnecessary.

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