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EVALUATION OF CBRN MATERIALS MAINTENANCE LABORATORY'S CONFORMITY WITH CNEN'S RADIOPROTECTION STANDARDS

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ABSTRACT

The present research aims to analyze radiological safety in the Mnt Mat DQBRN, a Chemical, Biological, Radiological, and Nuclear (CBRN) Laboratory, located at the Batalhão Central de Manutenção e Suprimentos (BCMS) in Rio de Janeiro, verifying its compliance with the regulations of the Comissão Nacional de Energia Nuclear (CNEN). The main objective is to conduct a radiometric assessment of the environment, aiming to measure radiation distribution and ensure protection for both occupationally exposed workers and other employees working in areas adjacent to the laboratory. The methodology adopted involved measuring the equivalent dose rate for gamma radiation, in microsieverts per hour (µSv/h), at various strategic points in the laboratory. Three Thermo Scientific - RadEYE PRD radiation detectors of the same model were used, along with a Cesium-137 radioactive source with an activity of 165 millicuries, manufactured on January 25, 1989. The selection of measurement points was carried out in accordance with the occupational factor established by CNEN Norm NN 3.01, Resolution 164/14, from March 2014. According to this standard, stakeholders must classify work areas with radiation or radioactive materials, categorizing them as controlled areas, supervised areas, or free areas, as appropriate, considering aspects such as the spatial distribution of radiation. Although the obtained results reveal a non-uniform radiation distribution in the laboratory environment, the dose rate values recorded at all points are below the safe dose limit of 1 µSv/h for a worker. Data analysis, taking into account the dose limits established by CNEN, demonstrates that the Mnt Mat DQBRN laboratory is following radiological safety standards, providing safe working conditions for both occupationally exposed individuals and other employees working in uncontrolled areas.

1. INTRODUCTION

The growing importance of ensuring safety in locations that handle radioactive materials reflects a global commitment to preserving human health, protecting the environment, and adhering to regulatory guidelines [4].

Currently, the responsible management of radioactive materials has become a crucial priority, given the constant evolution of technology and global interdependence. The increasing demand for nuclear energy and the multiple applications of radioactive substances highlight the urgent need to ensure their safe use for both occupationally exposed individuals and others in locations where these sources are utilized for various purposes [1].

In this sense, the pursuit of safety in facilities that handle radioactive materials is not limited to regulatory compliance measures but also requires a proactive mindset of continuous improvement. The effective implementation of training programs, advanced monitoring systems, and operational protocols is crucial in ensuring safety [2].

The Comissão Nacional de Energia Nuclear (CNEN), the agency responsible for regulating and overseeing activities involving ionizing radiation in Brazil, establishes safety standards and criteria that must be followed by all institutions dealing with radioactive materials (Law No. 4,118, 1962) [3].

Given the inherent complexity of handling these materials, this article aims to analyze a radiometric assessment conducted in the Mnt Mat DQBRN Laboratory. The purpose is to perform a radiological monitoring of the environment, verifying compliance with the regulations set by CNEN. Furthermore, the experiment was designed to understand the radiation distribution in the area.

2. METHODOLOGY

2.1. Selection of Measurement Points

The selection of measurement points was carried out in accordance with the occupational factor established by CNEN Norm NN 3.01, Resolution 164/14, from March 2014, updated in 2018. The main changes aimed to update definitions, improve the clarity of the text, and align the standard with the best international practices in radiological protection. According to this standard, stakeholders must classify work areas with radiation or radioactive materials, categorizing them as controlled areas, supervised areas, or free areas, as appropriate, considering aspects such as the spatial distribution of radiation.

The assessment covered various areas of the laboratory, both internal and external, and included strategic points that were previously identified on the architectural plan of the site. Additionally, the radiation source was positioned inside the laboratory, 2 meters from the door, on a table, placed on a lead box, as illustrated in Figure 1.

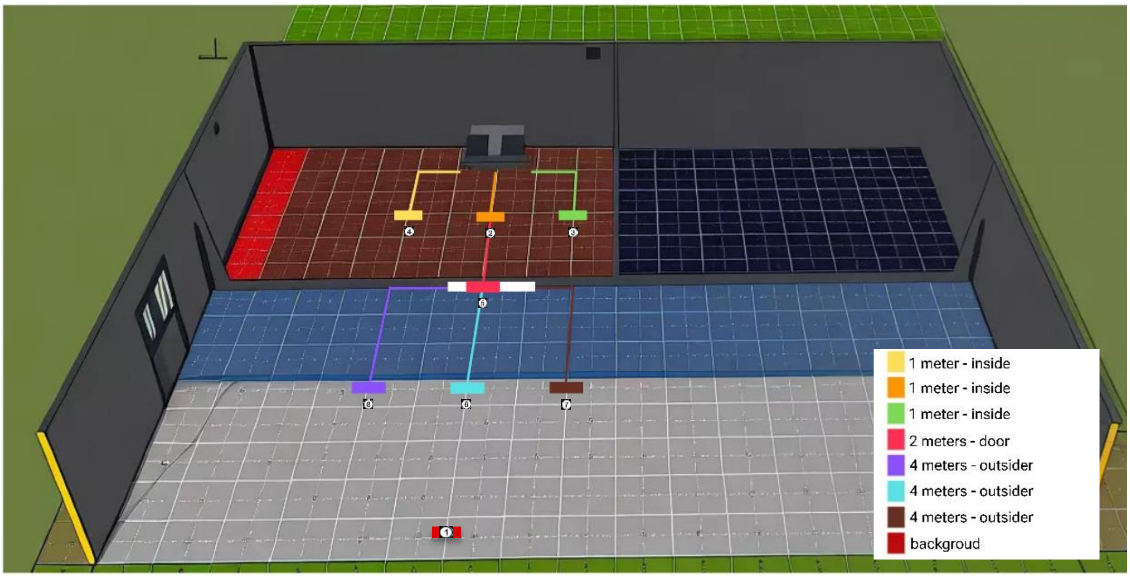

Fig. 1. Reduced architectural plan of the site where the experiment took place (Mnt Mat DQBRN Laboratory – RJ), highlighting the measurement locations. Each point is numbered as per Table 1.

2.2. Experimental Procedure

The experiment was conducted using three Thermo Scientific - RadEYE PRD-ER radiation detectors to ensure the reliability of the measurements and increase the precision of readings when detecting gamma radiation from a Cesium-137 radioactive source with an activity of 165 millicuries, manufactured on January 25, 1989. The measurements occurred in three distinct stages.

First, a background measurement was taken in the absence of the source, outside the laboratory, to establish the values of natural radiation exposure. Next, measurements were taken at the selected points in various locations, both inside and outside the laboratory, according to the previously identified layout. Finally, in the radiometric analysis phase, the results were interpreted based on the safety standards defined by CNEN, checking the compliance of the values with applicable norms and regulations for radiological safety.

The radiation source was positioned 2 meters from the door and inside the laboratory for two main reasons. The first was to simulate a real scenario where workers could be exposed to radiation when entering or leaving the laboratory. This setup allows for the assessment of the radiation to which workers are exposed on a daily basis, providing information about potential risks and the need for protective measures.

The second reason was to maximize the dispersion of radiation. By positioning the source inside the laboratory, radiation disperses throughout the environment, enabling the analysis of the spatial distribution of radiation at different points in the location. This approach is crucial for identifying areas with higher concentrations of radiation and for evaluating the effectiveness of existing radiological protection measures.

3. RESULTS

The values obtained from the radiation measurements in the laboratory are presented in Table 1. The measurements included the equivalent dose rate in microsieverts per hour (µSv/h) at each point for each detector.

Table 1: List of measurement points on the architectural plan of the experiment site. Numbered for reference during data collection.

Point	Distance from the Source	Detector 1 (µSv/h)	Detector 2 (µSv/h)	Detector 3 (µSv/h)
1	background	0.13	0.13	0.13
2	1 meter (inside - front)	0.43	0.54	0.51
3	1 meter (inside - to the right)	0.16	0.12	0.12
4	1 meter (inside - to the left)	0.14	0.11	0.14
5	2 meters (inside - front)	0.20	0.16	0.19
6	4 meters (outside - front)	0.16	0.14	0.15
7	4 meters (outside - to the right)	0.15	0.14	0.16
8	4 meters (outside - to the left)	0.15	0.16	0.15

The recorded background values (0.13 µSv/h for all detectors) indicate the natural radiation exposure in the environment and serve as a baseline for comparison for subsequent points.

The levels of radiometric exposure vary in different areas of the laboratory, indicating a non-uniform distribution of radiation. For example, in the second stage of the experiment (point 2), the exposure is higher compared to the third and fourth stages (points 3 and 4). These variations may be influenced by the proximity of the radiation source to certain measurement points and the presence of obstacles that alter the propagation of radiation.

Exposure at point 5 (in front - 2 meters from the source) increases compared to point 4, highlighting the greater influence of proximity to the radiation source. The presence of physical barriers between point 4 and the source, which are absent between point 5 and the source, may alter the propagation of radiation, resulting in higher exposure at point 5. Additionally, the position of the radiation source relative to the measurement points can also be a significant factor.

At the external points, point 6 (outside - in front of the source) shows lower exposure than point 2, indicating attenuation as one moves away from the laboratory, possibly due to physical barriers like walls and doors. Points 7 and 8, located outside the laboratory on the right and left sides, exhibit similar values, suggesting consistent exposure when moving to the outer sides, possibly reflecting a homogeneous radiation distribution in those directions.

4. CONCLUSION

However, it can be stated that, based on the results of the evaluation conducted, the battalion presents a scenario of compliance with CNEN regulations regarding radiological safety. Both controlled and uncontrolled areas were assessed, and the results indicate that the regulatory dose limits for radiation are being respected. This suggests that employees working in these areas can perform their activities within the maximum safe time established by the regulation, without exceeding the recommended exposure limits.

Additionally, the analysis also considered the safety of employees who are not directly involved in the handling of radioactive materials, such as maintenance staff, and the results indicate that they are protected within acceptable exposure limits. However, continuous monitoring and the implementation of additional safety measures are recommended, if necessary, to ensure the protection of workers in all areas of the battalion.

Therefore, based on these conclusions, we can affirm that the work environment in the Mnt Mat DQBRN Laboratory is safe in terms of radiation exposure, meeting the safety requirements established by CNEN.

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