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ASSESSMENT OF UTILIZING THE URUTU ARMORED FIGHTING VEHICLE IN RECONNAISSANCE ROLES

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ABSTRACT

Heavy metal materials are widely used for electromagnetic radiation shielding projects. In this context, an experimental study was conducted with the Urutu Armored Vehicle, adopting a non-collimated geometry, and using a Cesium-137 source to verify the electromagnetic radiation transmission factor of the vehicle in question. For the energy of Cesium-137, the original ballistic shielding of the combat vehicle showed a maximum transmission factor of approximately 88%.

1. INTRODUCTION

Modern military operations frequently expose personnel to a range of threats, including nuclear, biological, and chemical hazards, necessitating robust protective measures, particularly in armored vehicles. One critical threat is exposure to ionizing radiation, which can severely impact both the functionality of equipment and the health of military personnel.

Fig. 1. Urutu armored Fighting Vehicle

The Urutu APC, developed in the 1970s by the Brazilian defense company Engesa, represents a significant achievement in military engineering, offering mobility, protection, and versatility in the field. The EE-11 model, as shown in Fig. 1, has been a cornerstone of Brazilian military operations. Initially developed to protect personnel from conventional threats such as ballistic impacts and explosives, the vehicle's shielding capabilities have since been extended to consider radiological protection, making it an ideal candidate for use in reconnaissance missions, including those involving potential radiological hazards [1].

Understanding the effectiveness of the Urutu's shielding against ionizing radiation, particularly gamma radiation from sources such as Cesium-137, is vital in assessing its suitability for modern battlefield environments. Cesium-137, with an energy of 662 keV, poses a significant radiological threat, necessitating thorough experimental evaluations of vehicle shielding [2].

This article builds on previous studies of electromagnetic radiation shielding in military vehicles, focusing specifically on the ballistic and radiological protection offered by the Urutu's multilayered armor. The transmission factor, a critical parameter in radiation protection, has been measured for the characteristic energy of Cs-137. The aim of this investigation is to provide an assessment of the vehicle's protective capabilities, analysing the extent of radiation attenuation and the associated dose absorbed by crew members in an operational scenario.

This research contributes to the broader understanding of radiation protection in military contexts, where vehicles like the Urutu may be deployed in environments contaminated by radiological materials. By quantifying the vehicle's shielding effectiveness, this study offers valuable insights into its potential use in CBRN (Chemical, Biological, Radiological, and Nuclear) reconnaissance missions and enhances the overall strategy for safeguarding personnel in hostile environments.

2. METHODOLOGY

The materials used were: Urutu armored fighting vehicle, 3 Gamma radiation detectors RadEye [3], and a Cesium-137 source with an initial activity of 165 mCi and a manufacturing date of January 25, 1989.

The vehicle's experimental transmission factor was calculated by the Equation 1, where I stands for intensity after transmission, I_0 stands for initial intensity before transmission, and FT represents the Transmission Factor [4].

$$\frac{I}{Io} = FT \qquad (1)$$

Initially, direct irradiation of the cesium-137 source on the detector was performed five meters away in order to obtain the parameter *Io* of the Equation 1.

The parameter *I* of Equation 1 was measured while positioning the source inside the vehicle, placed on a radiological trifolium, and the detectors at the numbered points as illustrated in Fig. 2.

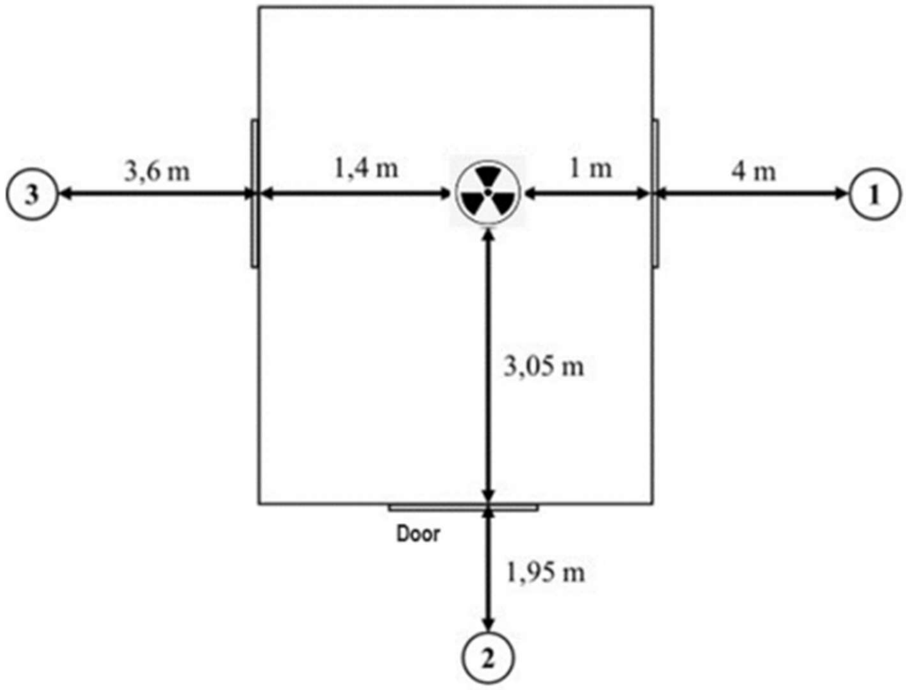

Fig. 2. Positioning of the radiological source and detectors

The measurement points were selected based on key positions within the vehicle where radiation exposure was anticipated to vary due to the structural and shielding differences of the vehicle. They were conducted only with the access doors closed, and it was assumed that the thicknesses of the ballistic shielding are equal at all 3 points. The maximum dose rate displayed by the detector was used. Since all measurements were taken in the same warehouse, there was no need to subtract background radiation.

The decision to place the radioactive source inside the vehicle for this experiment was made to control the exposure to which the researchers would be subjected. By positioning the source internally, the experimental setup ensured that the radiation exposure remained within safe and manageable levels for personnel conducting the study. This controlled environment allowed for more accurate measurements while minimizing health risks to the team.

Furthermore, this experiment's primary goal was to obtain a clear understanding of the vehicle's transmission factor (FT) under specific conditions. It is important to note that the FT values derived from a source placed inside the vehicle differ from those where the source is positioned externally. This is because the relative distances between the source, the shielding, and the detectors change, and the order of the shielding materials that the radiation passes through is also altered. External sources would result in different attenuation characteristics due to the layers of the vehicle's armor and air gaps, whereas an internal source more directly evaluates the vehicle's internal shielding effectiveness in a confined environment.

Therefore, this work provides a valuable baseline for understanding the vehicle's shielding capacity with internal radiation sources, but further studies would be necessary to measure and compare the FT for external radiation sources, which could result in different transmission values due to changes in distance and shielding configurations.

The materials between the radioactive source and the detectors consisted of multilayered ballistic shielding. To simplify the calculations, we will assume that this thickness is uniform across the entire vehicle. This configuration provides an outer steel layer for added protection, while the lightweight inner layers contribute to the vehicle's overall structural integrity and radiation attenuation. [9]

It is important to note that further details about the specific materials and composition of the ballistic shielding are classified military information and cannot be disclosed in this work. While the provided information offers a basic understanding of the shielding's structure, certain design elements related to the vehicle's protection systems must remain confidential for security reasons. As a result, a direct comparison between these results and theoretical calculations cannot be made, as the necessary information cannot be shared.

3. RESULTS

In Table 1, the presented results of the measurements of the dose rates from the source inside the vehicle are shown. The result of the measurement of the direct exposure of the source to the detector was 8.80 *Sv/h*.

Tab. 1. Results of the measurement using the armored Fighting Vehicle as a radiation attenuator.

Location	**Dose Rate (μSv/h)**
Point 1	4.24
Point 2	5.77
Point 3	7.75

Tab. 2 Presents the values of the transmission, which is dimensionless, by measurement position.

Tab. 2. Results of the transmission factor by position.

Location	**Transmission Factors**
Point 1	0,48
Point 2	0,65
Point 3	0,88

Contrary to initial expectations, Point 3's transmission factor did not follow the anticipated trend based on distance from the shielding. That might be due to the difference in shielding between different doors of the vehicle.

Due to the controlled environment and repeated measurements, uncertainty values were considered negligible and were thus not reported.

Another factor that influenced the measurement is that the vehicle's ballistic shielding is multi-layered, with the inner layers being made of lightweight materials and the steel being on the outermost part, thereby increasing the buildup factor [9].

The influence of the thickness of each material layer, particularly the inner lightweight materials and outer steel, should be considered when calculating the buildup factor, as varying thicknesses can significantly alter the transmission and absorption properties. However, due to the classified nature of specific details regarding the ballistic shielding, which were cited earlier, it was not possible to perform a detailed calculation.

4. DISCUSSION

Through this work, it can be concluded that the positions of the absorbers actively interfere in the shielding against radiation, as predicted in the literature [5], [6], [8].

Another possible conclusion is regarding the direct interference of the angle of incidence and radiation measurement. In theory, the greater the angle of incidence, the greater the scattering, hence higher exposures are expected, as also predicted in the literature [5], [6], [8].

The unexpected difference between the measurements at Points 1 and 3, which should theoretically be closer in value, could be attributed to several factors. Despite assuming uniform shielding thickness, variations in the vehicle's structure or the buildup factor may have affected the radiation attenuation at these points. Additionally, the geometry of the measurement setup and the possible influence of secondary radiation within the multilayered shielding could explain the higher-than-expected reading at Point 3. Further investigation into these variables could provide additional clarity [7].

In favor of the crew's safety, it can be said that the vehicle's transmission factor is 88% for the energy of Cesium-137. The measured transmission factor (FT) is expected as steel, while effective for stopping ballistic threats, is a relatively poor attenuator for gamma radiation. Gamma rays tend to pass through steel with less attenuation compared to denser materials such as lead, resulting in a higher transmission factor [11].

According to the ICRP's guidelines for radiation workers, the measured dose rates (ranging from 4.24 μSv/h to 7.75 μSv/h) are within acceptable limits for military operations. The limit for emergency operations is 500 mSv per year, which would allow up to 64.5 hours of exposure annually at these dose rates if we use the 7.75 μSv/h as a base [10].

However, it is important to note that for extended missions, additional evaluations might be necessary to ensure the crew's cumulative exposure remains safe. If the vehicle is deployed in high-radiation environments, enhancements to the shielding or operational procedures may be required to maintain acceptable radiation levels.

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