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MONTE CARLO SIMULATION OF A EXPLOSIVES DETECTION SYSTEM BASED ON A D-D NEUTRON GENERATOR AND NaI(Tl) SCINTILATORS

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INTRODUCTION

The increase in the global terrorist threat defines the fundamental objectives and features of Explosive Detection Systems (EDS's): 1) To employ safe and effective technologies that reduce inspection times; 2) Reduce the rate of erroneous inspections or false positives; 3) Reduce the false negative rate to zero; 4) To be able to detect new explosives; and, of course, 5) Reduce the operation costs and implementation of the detection system [1]. The main properties of explosive materials are their high density (1.2-2 g/cm^3) and their composition (mainly N, O, C and H) [2]. The new impulse of neutron techniques is based on the great technological increase of the main components of these systems: 1) Development of compact, cheap, portable and safe neutron sources, using compact generators based on DD or DT fusion reactions; 2) More efficient and cheaper gamma radiation detectors, 3) More efficient and secure data acquisition systems [3].

The aim of this work is to study the performance of a explosive detection system (EDS), using Monte-Carlo neutron-transport, with the MCNP6 code under realistic conditions. The EDS is based on a D-D neutron generator, gamma-ray NaI (Tl) detectors and high-density polyethylene (HDPE) moderator. The explosives simulated are RDX and AN.

MATERIALS AND METHODS

The neutron source is a commercial DD neutron generator model DD-110 (**Figure 1**). This generator can produce a field of 10^{10} n/s with energy 2,5 MeV [5]. The gamma ray detectors are scintillators with NaI(Tl) crystals [6], with two different sizes, 1,5"x1" and 3"x3", respectively (**Figure 2**). The moderator selected has been HDPE, due to their high density, high-rise performance and low cost [6]. The set has a volume of 0,64 m^3 and a weight of 660 kg, (**Figure 3**). The simulated explosives samples have been 931,84 grams of RDX (cyclonite) and 883,2 grams of AN (Ammonium nitrate). The design of the EDS has been modelled and optimized with Monte Carlo Methods (MCNP6), similar to one designed by Bergaoui et al. [4].

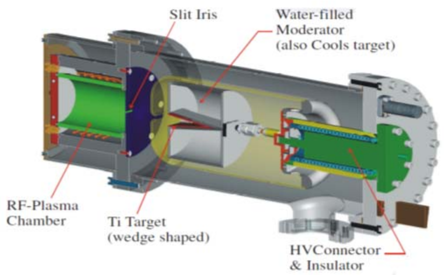

Figure 1: Neutron generator Adelphi model D-D 110 [5]

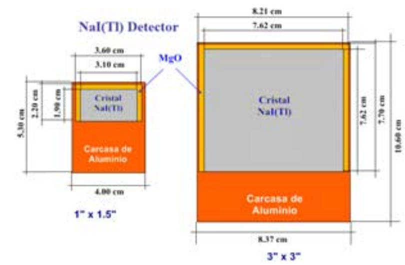

Figure 2: Model of the NaI(Tl) scintillators

Monte Carlo Calculations (MCNP6)

1. Sample statistics was large enough to obtain uncertainties lower than 3%. The cross sections were obtained from the END/B-VI library [8].
2. The complete EDS has been modelled considering three different configurations (**Figure 4**) [9].
3. The Gaussian Energy Broadening (GEB) has been used to improve the energy resolution of the detectors considered in the simulations [10].

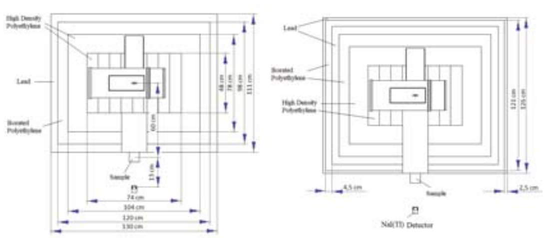

Figure 3: Set model for MCNP of the explosives detection system

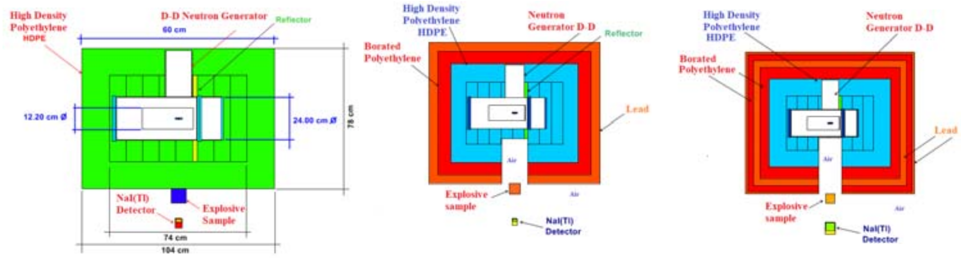

Figure 4: Different configurations of explosives detection system (EDS) used in the simulations

RESULTS

The Results have been obtained for the two explosives mentioned above (RDX, AN), for each of the three different configurations (1, 2, 3), with each size of the detector (1,5"x1" and 3"x3). The results for the RDX with configuration 3 are shown (**Figure 5**). The analysis of the neutron ambient equivalent dose H*(10) has been performed for each configuration (**Figure 6**).

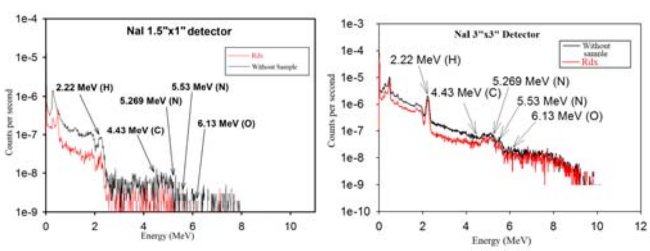

Figure 5: Results of RDX sample with configuration 3 and two different detectors size

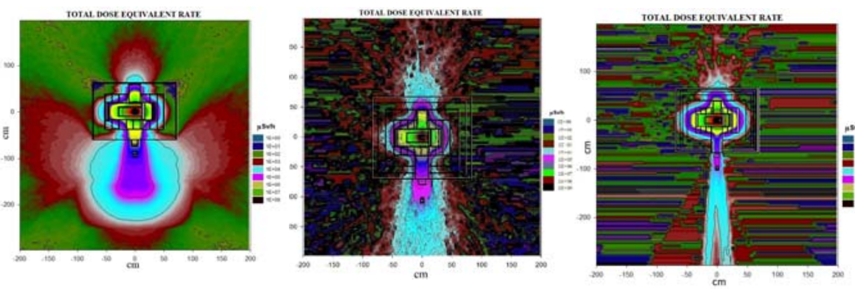

Figure 6: Dose and neutron field in the three different configurations

CONCLUSIONS

1. **The performance of a explosive detection system in operational conditions was calculated using Monte Carlo methods. The EDS is based on a D-D neutron generator, gamma-ray NaI (Tl) detectors and HDPE moderator.**
2. **The best thermal neutron flux is obtained with configurations 2 and 3, while the lowest ambient dose H*(10) is obtained with configuration 3.**
3. **The best performance and measurement of gamma radiation is obtained with the 3"x3" NaI(Tl) detector.**

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