INTRODUCTION

A new deuterium-deuterium (D-D) neutron generator has been developed for non-destructive neutron inspection techniques. The neutron generator is composed of three major components: An RF-Induction Ion Source, the Secondary Electron Shroud, and the Diode Accelerator Structure and Target. It generates monoenergetic neutrons (2.5 MeV) with a neutron yield of $10^{10}$ n/s using 25-50 mA of beam current and 125 kV of acceleration voltage. Three nuclear analytical techniques were tested and optimized to be used with the neutron generator: (1) Prompt γ-ray neutron activation analysis (PGNAA) of 10B concentrations in Si and SiO2 matrices was carried out using a germanium detector (HPGe) and the results obtained are compared with a PGNAA system using a NaI detector. (2) The radiography facility used in the measurements and simulations employs a fully high-voltage-shielded, D-D neutron generator. Both fast and thermal neutron images were acquired with the generator and a Charge Coupled Devices camera. To shorten the imaging time and decrease the noise from gamma radiation, various collimator designs were proposed and simulated using MCNPX. Design considerations included the choice of material, thickness, position and aperture for the collimator. (3) Optimization of a D-D neutron generator based explosive detection system (EDS) was performed using Monte-Carlo simulation. The shape and the thickness of the moderators and shields are optimised to produce the highest thermal neutron flux at explosive position and the minimum total dose at the outer surfaces of the explosive detection system walls. In addition simulation of the response functions of NaI, BGO, and LaBr₃-based γ-ray detectors to pure chemical elements is described.

D-D NEUTRON GENERATOR

Characterization and Measurement of the neutron yield of the D–D neutron generator

The generator consists of three major components: RF-Induction Ion Source, the Secondary Electron Shroud, and the Diode Accelerator Structure and Target. It is designed to produce a yield of $10^{10}$ neutrons per second with a 2.5 MeV energy through the following DD fusion reaction.

$$^2D + ^2D ightarrow ^4He + ^1H + 2.5MeV$$

The highest neutron output was achieved with an acceleration voltage of 125 kV and RF input power of 2.5 kW. The production of monoenergetic neutrons (2.5 MeV) with a neutron yield of $4.5x10^{10}$ n/s was achieved.

PGNAA OF BORON WITH D-D NEUTRON GENERATOR

PGNAA experimental setup

Sample preparation

Boron measurement with HPGe and NaI detector

- From the boron measurements conducted in this system performance study, the thermal neutron absorption cross section could be calculated to within 3.8%.

REFERENCES


EXPLOSIVE DETECTION SYSTEMS (EDS) WITH D-D NEUTRON GENERATOR

- The photo peak of the (8x4") detector is larger than that of the (3x3") and (5x5"x10") detectors.
- LaBr₃ detector has higher resolution than both the NaI(Tl) and BGO detectors.

CONCLUSIONS

- The study performed here demonstrates that D-D neutron generators with an output of $10^5$ to $10^{10}$ n/s can successfully be used for PGNAA.
- D-D neutron generator is suitable for neutron radiography, the collimator provides significant improvement in neutron flux and a decrease in background radiation compared to the experimental arrangement.
- The 2.5 MeV neutrons produced from the D-D neutron generator with an output of $10^5$ n/s could be used to detect explosives with an (8x4") NaI detector.