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Development of active neutron nondestructive assay system

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There is no acceptable and practicable single nondestructive method for the assay of Special Nuclear Materials (SNM) and Minor Actinides (MA) in highly radioactive nuclear materials, such as those found in spent fuel and MA transmutation fuel. The Japan Atomic Energy Agency (JAEA) and the Joint Research Centre (JRC) of the European Commission have been developing an active neutron nondestructive assay (NDA) system for nuclear non-proliferation and nuclear security [1]. We utilize four different NDA techniques, namely Differential Die-Away Analysis (DDA), Prompt Gamma-ray Analysis (PGA), Neutron Resonance Transmission Analysis (NRTA) and Delayed Gamma-ray Anal- ysis (DGA) [2]. These are promising and effective active neutron techniques especially for nuclear material accountancy. The techniques give us different and useful analytical results, which could provide complementary information. We developed a combined NDA system, which enables the simultaneous measurements of DDA and PGA, at NUclear fuel Cycle safety Engineering research Facility (NUCEF) in the first phase of the collaboration. The conventional DDA utilizes a thermal neutron for the interrogation. The combined NDA system can be used an improved DDA. It has rather uniform sensitivity for fissile materials because fast neutrons are used for the interrogation. Moreover, it is possible to quantify a small amount of the fissile mass as low as 1mg(Pu-239) [3]. PGA is efficient adaptive NDA method to apply for the measurement of light elements and therefore is utilized for the quantification of neutron absorber and is particularly useful for the detection of ex- plosives. The second phase of the project, launched in 2018, focuses on the development of the active neutron NDA system for highly radioactive materials. We conducted further study to improve the methodologies and developed an advanced NDA system which allows us to measure by NRTA as well as DDA and PGA. The third phase has started to study a compact NRTA system from 2022 for four years. NRTA can be used to quantify almost all medium and high-Z elements and considered as one of the most accurate NDA techniques to quantify the amount of SNM and MA. In addition, NRTA would be the most promising method in terms of the low-background measurements for highly radioactive nuclear materials because the detector can be set up farther away from the highly radioactive samples. An overview of the projects and the recent results will be presented, especially the details of new integrated NDA system.

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[1] M. Kureta et al., Proceedings of 37th ESARDA Symposium on Safeguards and Nuclear Non- Proliferation, Manchester, UK, p111-120 (2015).

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