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#4-85 Reactor test of beryllium as self-powered neutron detector emitter for fast neutron flux measurement

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Neutron flux in nuclear reactors causes damages to material components. Fast neutrons, above 1 MeV, can modify mechanical and structural properties of materials. These damages are expressed as displacements per atom (dpa). Some experiments carried out in research reactors study the behaviour and ageing of materials irradiated by high neutron fluxes. In these experiments, it is therefore essential to monitor fast neutron flux to which tested materials are exposed. The selective on-line measurement of fast neutron flux in a water-pool type reactor environment remains an in-core measurement challenge. The aim of this work is to experimentally validate the use self-powered neutron detector technology to monitor fast neutron flux in a water-cooled reactor.

A self-powered neutron detector (SPND) is a coaxial detector that operates without high voltage supply. It is composed of three components: an emitter, an insulator and a sheath. Operating only for high fluxes, SPND is ideally adapted to on-line monitoring of irradiation experiments. Material choice and, in particular, emitter choice favour interactions with specific particles of interest. In our case, SPND material design must maximize fast neutron contribution. After a systematic review of the periodic element table, beryllium appears to be the most suitable emitter material for measurements sensitive and selective to fast neutrons. Due to its threshold cross section to fast neutrons and its low interaction probability with gamma rays, beryllium seems the appropriate candidate as emitter material for reactor environment use. Few beryllium SPND prototypes are designed and manufactured. This presentation first details the final prototype design, composed of beryllium emitter, MgO insulator and Inconel600®sheath.

In June 2024, beryllium SPND prototypes have been tested in the Slovenian TRIGA Mark II reactor (Jožef Stefan Institute). Tests first qualified the irradiation locations with different measurements techniques such as dosimetry, standard SPND measurements and axial profiles with fission chambers and ionization chamber. It also validates the irradiation conditions (thermal neutrons, fast neutrons, and gamma rays) in support of dedicated TRIPOLI4® calculations for each experimental location.

Then, the study goes on performance analysis of the beryllium SPND prototypes in a real reactor environment. The analysis yields encouraging outcomes, particularly following a comparison with SPND numerical modelling. These results permit an evaluation of beryllium benefits as an emitter. It also concludes with a potential improved design simplifying SPND fast neutron measurement.

These specific reactor tests in well-characterized irradiation conditions enforce fast neutron SPNDs as a new option for on-line monitoring of technological irradiations.

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