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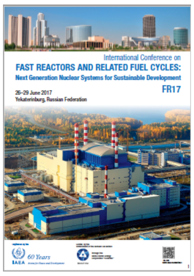

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Dependability of the fission chambers for the neutron flux monitoring system of the French GEN-IV SFR

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Sodium-cooled fast reactors (SFR) have been selected by the Generation IV International Forum, thanks to their capability of reducing nuclear waste and saving nuclear energy resources by burning actinides. With reactors such as RAPSODIE, PHENIX and SUPER PHENIX, France gained a 50 year experience in designing, building and operating SFR: since 2006 the CEA leads the development of an innovative GEN-IV nuclear-fission power demonstrator. As a part of it, the neutron flux monitoring system must, in any situation, permit both reactivity control and power level monitoring from startup to full power. It also has to monitor possible changes in neutron flux distribution within the core region in order to prevent any local melting accident. This implies to install the neutron detectors inside the vessel, putting severe constraints on the detector design to ensure its dependability, that is, both its reliability and maintainability.

In this paper, we present the Photonis high-temperature fission chambers (HTFC) featuring wide-range flux monitoring capability and justify their specifications with the use of simulation and experimental results.

We show that the HTFC dependability is enhanced thanks to a robust physical design and that the mineral insulation is insensitive to any increase in temperature. Indeed, the HTFC insulation is subject to partial discharges at high temperature when the electric field between their electrodes exceeds 200 V/mm or so. These discharges give rise to signals similar to the neutron pulses generated by a fission chamber itself, which may bias the HTFC count rate at startup only. However, we have experimentally verified that one can discriminate neutron pulses from partial discharges using online estimation of pulse width.

In order to satisfy the requirement of wide-range capability, we propose to estimate the count rate of a HTFC using the third-order cumulant of its signal. The use of this cumulant can be seen as an extension of the so-called Campbeling mode, based on the variance, hence the name high order Campbelling method (HOC). The HOC ensures the HTFC response linearity over the entire neutron flux range using a signal processing technique that is simple enough to satisfy design constraints on electric devices important for nuclear safety. The simulations are supported by experimental results that demonstrate that the HOC agrees with the simple pulse counting estimation at low count rates and provides a linear estimation of the count rates at higher power levels.

Country/Int. Organization

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