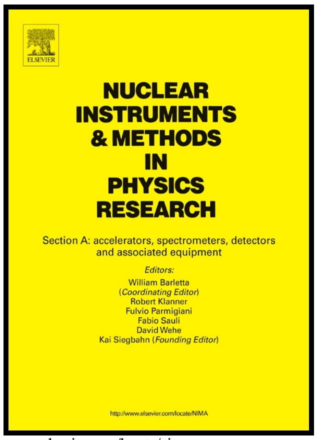

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Rejection of partial-discharge-induced pulses in fission chambers designed for sodium-cooled fast reactors

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Abstract

Under given temperature and bias voltage conditions, partial discharges can create pulses in fission chambers. Based on experimental results, this phenomenon is in-depth investigated and discussed. A pulse-shape-analysis technique is proposed to discriminate neutron-induced pulses from partial-discharge-induced ones.

Keywords: Sodium fast reactor. Neutron detection. High Temperature Fission Chamber. Partial Discharge. Pulse shape analysis

I. INTRODUCTION

FAST neutron sodium-cooled reactors (FSR or SFR for Sodium-cooled Fast Reactor) are one of the advanced reactors selected by the Generation IV International Forum.

Fission chamber has been identified as the most suitable neutron detector to be used in the vessel of a sodium fast reactor [1-3]. This detector namely High Temperature Fission Chamber (HTFC), must be able to operate under high irradiation up to 10^{10} n/cm².s and high temperature up to 650°C. One of the effect of this hostile environment is the superposition of a partial discharge signal to the useful signal measured with a fission chamber. Theoretical studies have defined the phenomenon of partial discharges (PD) in gases and solids. Indeed, partial discharges occurring in the gas are known as “Corona partial discharges” [4], whereas partial discharges occurring in solids are called “electronic avalanche” [5] [6]. In this paper, we show experimental results obtained with three HTFC at different values of temperature and bias voltage, under neutron beam irradiation and off beam.

This paper is organized as follows: in Section 2, an overview of the methodology used to carry out these tests is presented. In Section 3, results off beam will be shown. In Section 4, results of beam tests will be presented, discussed, and compared to those off beam.

II. EXPERIMENTAL DETAILS

Our objective is to understand what are the operational conditions, mainly in terms of temperature and bias voltage. Indeed, these two parameters could be the cause of partial discharges in HTFC. Three identical chambers are tested. All of them are placed together in a tubular furnace which can reach a temperature of 650 ° C. Temperature is increased gradually. Several types of electronics and outputs were used for collecting and processing the signal obtained from PD and neutron pulses. Each HTFC was coupled to a CANBERRA 7820 amplifier. This module has two outputs: an analog output and a logic output (TTL). Whereas TTL signal allows for characterizing arrival time distribution of the observed pulses, analog signal allows for investigation of their shape and amplitude. The amplifier was controlled through the GENIE 2000 CANBERRA software. The TTL output is connected to both a standard counter/timer and the PING time-stamping acquisition system, developed at the French Atomic Commission (CEA) [7]. The PING instrumentation allows for measuring the time elapsed between two subsequent pulses. Pulses (analog output) measurements are performed with a large bandwidth digital oscilloscope (20 giga-samples/s, 10 bits). A block diagram of the experimental setup is shown in Fig. 1.

Tests under irradiation have been performed at the SAPHIR facility [8] which is located at CEA in Saclay (France). The SAPHIR facility houses two electron accelerators. A 15 MeV electron accelerator has been used as a neutron source for these experiments. Neutrons, known as photoneutrons are produced by photonuclear reactions in the target of the accelerator [9]. A target made of tantalum has been used for these experiments. Maximum neutron fluence is about 10^7 n/cm².s. The gamma dose rate is about 10 Gy/hour. The same electronics were used to perform the beam tests and off beam.

Characteristics of the three HTFCs are similar and are given in Table 1. In the following, the three HTFC will be named A, B and C.