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Application of prompt gamma source for N-16 detector system calibration

Tufic Madi Filho, José Patrício Náhuel Cárdenas and Antonio Carlos Iglesias Rodrigues

Instituto de Pesquisas Energéticas e Nucleares (IPEN / CNEN - SP)
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
tmfilho@usp.br, ahiru@ipen.br, acirodri@ipen.br

ABSTRACT

Nuclear research reactor power monitoring and control need to be redundant. In the IEA-R1 nuclear research reactor, three safety channels are used. First safety signal is derived from a fission chamber used in the start up reactor. A second and third safety channels use a non-compensated ionization chamber to measure neutron and gamma production. To control the power of reactor a linear channel with a compensated ionization chamber is used to detect only neutrons production. The power control system of the nuclear reactor is an important tool that concerns the safe operation. Another redundant system used is the measurement of ^{16}N rate. Power monitoring is carried out using a ^{16}N especial channel, as well. ^{16}N rate production may be used to monitor the power reactor due this element high production during the reactor operation. The nuclear reaction:, $^{16}O(n, p)^{16}N$ produces a 7.5 second decay time unstable isotope, emitting a gamma ray in a range between 5 to 7 MeV energy. In order to measure the 16N, the detector system should be calibrated to cut off the gamma ray energy below 5.0 MeV. In this work a source of prompt gamma using polyvinyl chloride and AmBe neutron source is proposed for calibrate the ^{16}N detector system.

1. INTRODUCTION

Nuclear research reactor power monitoring and control need to be redundant. In the IEA-R1 nuclear research reactor, three safety channels are used. First safety channel signal is derived from a fission chamber used in the reactor start up. A second and third safety channels use a non-compensated ionization chamber to measure neutron and gamma production. To reactor power control a linear channel with a compensated ionization chamber is used to detect only neutrons production. The power control system of the nuclear reactor is an important tool concerning the safe operation [1].

Another redundant system used is the measurement of ^{16}N rate. Power monitoring is carried out using a ^{16}N especial channel, as well. ^{16}N rate production may be used to monitor the power reactor due this element high production during the reactor operation. During the reactor operation, the fission neutron interact with the oxygen atom present in the water around the reactor core, and produce ^{16}N according to the following $^{16}O(n, p)^{16}N$ reaction. However, it should be recognized that the signal from a ^{16}N detector will be delayed relative to the true core power by the time required for the primary coolant to flow from the reactor core to the detector location. [1]

The nuclear reaction: $^{16}O(n, p)^{16}N$, emitted, during the ^{16}N decay, beta and gamma. Gamma photons emissions are in a range between 5 and 7 MeV energy (6.13 MeV) [2, 3].

In order to measure the ^{16}N, the detector system should be calibrated to cut off the gamma ray energy below 5.0 MeV. In this work a source of prompt gamma using polyvinyl chloride and AmBe neutron source is proposed for calibrate the N-16 detector system.

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2. MATERIALS AND METHODS

In this work, in order to produce the prompt gamma source were used: (a) PVC block, (b) Graphite block, (c) Water and AmBe neutron source. Prompt gamma measurements were made using an HPGe detector, Figure 1. This procedure was based in previous work [4]

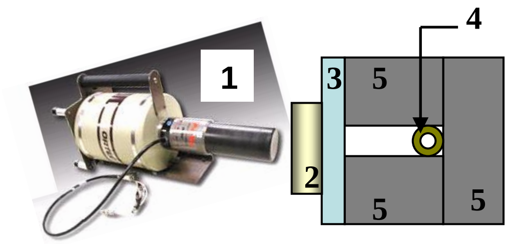

Figure 1. Diagram of the measurement system, 1-HPGe, 2-PVC block, 3-Water, 4-AmBe source, 5-Graphite block.

3. RESULTS

Figure 2 show the gamma prompt spectrum obtained witch the HPGe detector, Table 1 present the gamma ray energy spectrum.

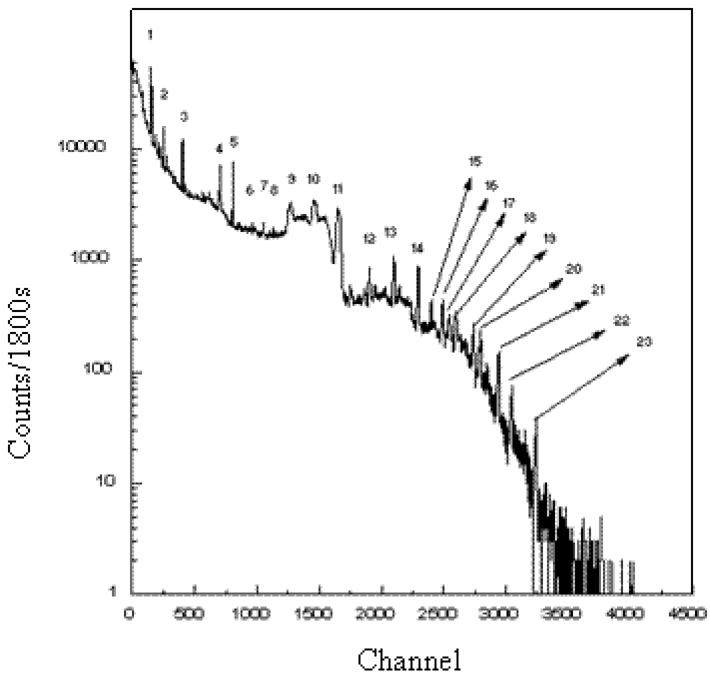

Figure 2. Prompt gamma spectrum of ^{36}Cl

TABLE 1 – Photo peaks of the ^{35}Cl (n, γ)^{36}Cl reaction, besides additional peaks of first and second escape.

Peak number	Photo peak [5] (keV)	Intensity [5] (%)	Escape Type
1	517.077	23.4	
2*	786.303 788.433	11.2 16.9	
3*	1164.870	27.7	
	1601.078	3.48	
4*	1951.146 1959.355	20.2 12.9	
7*	2863.835	6.55	
8	3061.845	3.88	
12	4979.757	3.60	1 e 2
14*	5715.236	5.60	1 e 2
15*	6110.840	20.2	2
16*	6619.615 6627.823	7.80 4.83	
18	6977.838	2.32	1 e 2

4. MOTIVATION FOR THE WORK

The reason of this work development is the fact that the research group intends to implement a ^{16}N measure system, using a plastic scintillator detector. The detector of this system has a cylinder form, with 50mm in diameter and 130 mm in length. This system, Figure 3a, will be calibrated to monitoring the Reactor IEA-R1 power. The water pump will take water on the reactor core, then, it will fill the water container, where the ^{16}N will be measured, Figure 3b. This detection system was used in previous work [6].

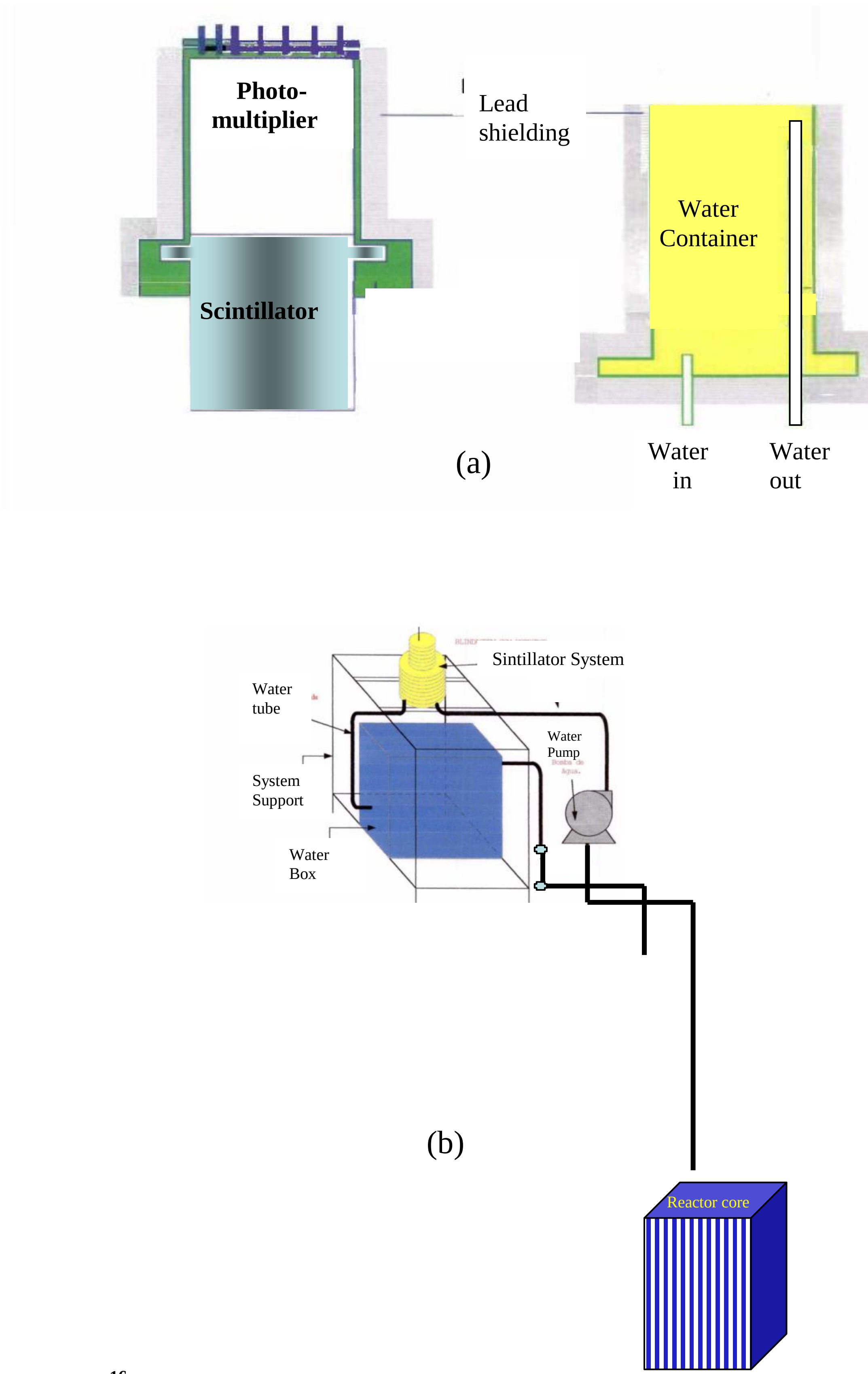

Figure 3. **^{16}N plastic scintillator detector system. (a) Arrangement for the scintillator detector, (b) scheme to take the water for measurement**

5. CONCLUSIONS

Using an electronic nuclear system, it is possible to establish an energy range between 5 and 7 MeV, thus avoiding interference from other possible elements that can be detected, when the ^{16}N measurement and the nuclear reactor power calibration are carried out.

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