Measurement of Detector Parameters of Neutron Coincidence Counter for Nuclear Material Accountancy

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1. Introduction

The Advanced spent fuel Conditioning Process Facility (ACPF) in KAERI has been refurbished for the demonstration of the technologies related to the oxide reduction process of pyroprocessing [1]. The ACPF can provide good opportunities not only for process purposes but also for safeguards technologies. In this study, a well-type passive neutron coincidence counter, called ASNC (ACP safeguards neutron counter), was developed and its detector parameters were measured.

2. ACP safeguards neutron counter (ASNC)

The ASNC, based on the passive neutron coincidence measurement technique, measures the amount of 244Cm. Based on that measurement, the amount of nuclear material subsequently can be determined by using the Cm balance technique, which multiplies the measured 244Cm amount by the Pu/244Cm or 235U/244Cm ratio to calculate the amount of nuclear material of interest (Pu or 235U). This ratio can be obtained by a destructive analysis, gamma-ray spectroscopy, or burnup-code calculation. In a previous study [2], the ASNC was installed in a hot cell of the ACPF and tested successfully with spent fuel rod cuts. However, its inner structure, with a horizontally-laid geometry, becomes deformed over the course of many years due to the weight and the ductility of the leaden gamma-ray shield. To address this problem, the ASNC was to be redesigned for a vertically-standing geometry based on the MCNP simulation and irradiation test results. Fig. 1 shows the modified ASNC.

Fig. 1. Modified ACP Safeguards Neutron Counter.

3. Detector parameters

Various detector parameters are needed to be determined in order to characterize the measurement system and to correct the measured data. The parameters determined in this study were operating voltage, dead-time correction factors, and efficiency profile.

Fig. 2 shows the high-voltage plateaus for 24 ^{3}He detectors installed in the ASNC. The gains of detectors with associated electronics were matched to each other and showed good agreement between the

detectors. The operating voltage was determined as 1720 V from the measured high-voltage plateau.

The dead-time corrected singles (S_c) and doubles (D_c) can be expressed as follows:

$$S_c = S_m \times e^{\frac{1}{4}\delta S_m}, D_c = D_m \times e^{\delta S_m} \qquad (1)$$

where S_m and D_m is the measured singles and doubles count rate, respectively. δ is the dead-time coefficient and given by $\delta=A+B\times S_m\times 10^{-6}$ where A and B are constant. The A and B were determined to be 2.1286×10^{-6} and 1.1328×10^{-12}, respectively, by using a two source method.

The detection efficiency profile in the axial and radial directions was measured for a ^{252}Cf standard source in order to characterize the system and verify the MCNP model. Ideally, a good system shows the same efficiency regardless source locations, resulting in low measurement error. The system showed flat response in terms of the measured efficiency, as shown in Fig. 3. In addition, the simulated results showed excellent agreement with the measured data, which confirmed the accuracy of the MCNP model for the measurement system.

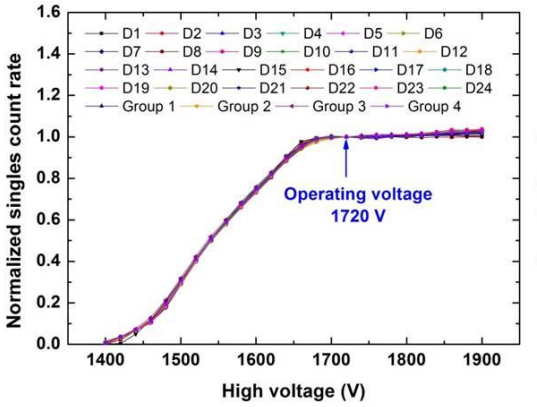

Fig. 2. Modified ACP Safeguards Neutron Counter.

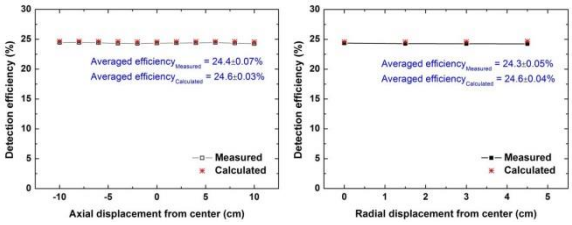

Fig. 3. Modified ACP Safeguards Neutron Counter.

4. Conclusion

The modified ASNC will be tested with the spent fuel rod cuts for calibration and with the input and output materials of oxide reduction process for evaluation of the performance.

REFERENCES

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