APPENDIX-I

Summary of Sensitivity Evaluation on the Sodium Sampling Method for Fuel Cladding Failure Location System

by

Tsutao HOSHI

Koichiro NAKAMOTO

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Fast Breeder Reactor Development Project

Power Reactor and Nuclear Fuel Development Corp.

9-13, 1-Chome, Akasaka, Minato-Ku

Tokyo, Japan

〒319-1184　茨城県那珂郡東海村大字村松4番地49
核燃料サイクル開発機構
技術展開部　技術協力課

Technical Cooperation Section,
Technology Management Division,
Japan Nuclear Cycle Development Institute
4-49 Muramatsu, Tokai-mura, Naka-gun, Ibaraki, 319-1184
Japan

1. Computational Model

A simplified computational model having been used is shown in Fig. I-1, and the assumptions for the calculation are as follows;

1) Nuclear characteristics of the core is represented by a point and the blanket is not taken into account.

2) Uranium contained in sodium coolant as impurity and fissionable nuclides on the surface of the fuel pins of both the core and the blanket are considered to be the source of the background. Gamma and neutron backgrounds from the reactor are ignored in this evaluation because it can be suppressed down by the shielding.

3) It is postulated that the fission products released from a cladding rupture disperse in the assembly with complete mixing.

4) The fission products after having returned to the reactor core through the primary coolant system are ignored of their effects.

The signal and the background to be detected as the counting rate of the delayed neutrons (C_{DN}) can generally be expressed by the following equations:

Signal

Continuous release;

$$C_{DN} = \sum_i N_F \sigma_f \phi Y_i e^{-\sigma_f \phi t} (1 - e^{-\lambda i \Delta t}) e^{-\lambda i td} \varepsilon V / Wc$$

$$\Delta t = 1 \text{ (sec)}$$

Burst;

$$C_{DN} = \sum_i N_F \sigma_f \phi Y_i e^{-\sigma_f \phi t} (1 - e^{-\lambda it}) e^{-\lambda i td} \varepsilon V / Wc$$

Background

$$C_{DN} = \sum_i N_{BG} \sigma_f \phi Y_i e^{-\sigma_f \phi t^*} (1 - e^{-\lambda i tc}) e^{-\lambda i td} \cdot \varepsilon V$$

$$t^* = tc \cdot t / tr$$

Where,

N_F : No. of atoms in fissile materials released

N_{BG} : No. of fissile atoms in 1 litre of sodium

σ_f : Microscopic fission cross section of fissile nuclei (cm^2)

ϕ : Core average neutron flux (n/cm^2 sec)

Y_i : Fission yield for the i-th group of delayed neutrons

λi : Decay constant of the i-th group (sec^{-1})

t : Reactor operating time (irradiation time) at full power (sec)

t_d : Transit time from core to detector position (sec)

t_c : Transit time through the core (sec)

t_r : One round time of sodium coolant through the primary coolant system (sec)

W_c : Sodium flow rate through an assembly (lit/sec)

ε : Detection efficiency of the sampling chamber per litre (cps/lit)

V : Volume of the sampling chamber (litre)

2. Results of Calculation

The S/N ratio was calculated under the following conditions;

1 Signal level is due to the fission of PuO_2-UO_2 in the amount of 10 mg.

2 Background level is due to the fission of uranium of 50 ppb contained in sodium.

3 The reactor parameters are as Table 1 of the master paper.

4 $\varepsilon = 10^{-1}$ and V = 0.3 (lit)

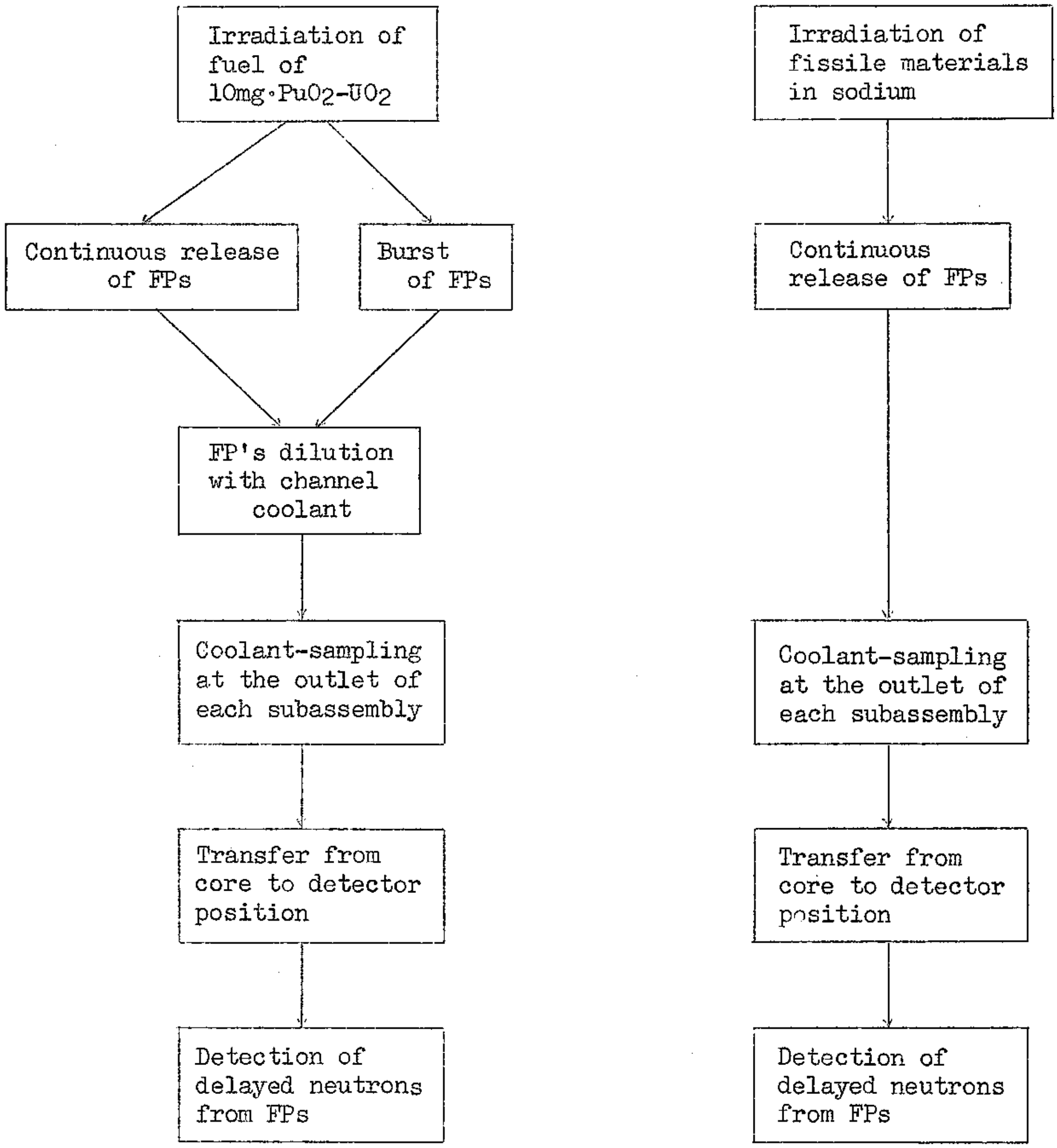
The results of calculation are shown in Table I-1.

As a reference, if the continuous release is based on recoil fission products, the amount of fission products from PuO_2-UO_2 of 10 mg can be given by the exposure area of 1.7 cm^2 of the fuel meat.

Table I-1. Results of Calculation

	Signal		Bakcground
	Continuous release	Burst	
Amount of fissile materials	10 mg (PuO_2-UO_2)		45 μg/lit* (Nat. U)
No. of delayed neutrons in sampling chamber	1.3×10^3 (dps/lit)	4×10^4 (dps/lit)	1×10^3 (dps/lit)
Counting rate by detection system	39 (cps)	1200 (cps)	30 (cps)
S/N	1.3	40	---

* 50 ppb impurity in sodium



(a) Signal (b) Background

Fig. I-1. Calculational Model