APPENDIX-II

Summary of a Study on the Tagging Method for Fuel Cladding Failure Location System

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1. Introduction

The tagging method has advantages over the other methods of sampling and FP gas bubble detection, because it is easily adopted without major modification of upper structures of the reactor core.

It will be said that Xenon (Xe) isotopes are most suitable ones for tag-gasses because of the following advantages;

(1) Xe concentration in argon cover gas during normal operation is very small (0.0009%) in comparison with other inert gasses as shown in Table II-1.

(2) Xe has many stable isotopes, for instance, Xe-124, 126, 128, and 129.

(3) Xe can easily be separated from argon gas by means of charcoal bed, gas-chromatography or other methods, since it is of higher boiling temperature and strong affinities than argon.

It is, however, difficult to obtain the Xe isotopes commercially in Japan at present. Therefore, a survey of some other inert gases has been carried out to investigate the possibility for tag-material. Neon (Ne) isotopes were after all selected and evaluated.

Summary of studies on the neon gas are described in the following section.

2. Sensitivity Evaluation

Characteristics of Neon for Tag Gas

There are three stable isotopes of Ne; Ne-20, Ne-21 and Ne-22 and their natural abundance ratio is about 90.92%, 0.26% and 8.82%, respectively.

The concentration of natural neon (0.19%) in argon cover gas is higher than that of Xenon (0.0009%) as shown in Table II-1.

In the prototype fast reactor, "MONJU", the volume of reactor cover gas is about 22 m^3, therefore, the amount of Ne isotope in the cover gas is calculated as follows;

Ne-20; $22 \times 10^6(ml) \times 0.0019 \times 0.9092 \simeq 3.8 \times 10^4(ml)$

Ne-21; " $\times 0.0026 \simeq 1.1 \times 10^2(ml)$

Ne-22; " $\times 0.0882 \simeq 3.7 \times 10^3(ml)$

Estimation of Detection Sensitivity

It will be expected to identify the failed pin, if, upon the fuel failure, the concentration of tagged-gas-isotope in unit volume of reactor cover gas increases over about 10% ($S/N > 0.1$) as compared with that of normal reactor operation.

Therefore, sensitivity has been evaluated with S/N ratio, where

S ; deviation of concentration of taged-gas-isotope in the reactor cover gas after fuel pin failure,

that is

$$\frac{\text{volume of tag gas seed in a fuel pin}}{\text{volume of cover gas}}$$

N ; concentration of tagged gas isotope in the reactor cover gas under normal reactor operation,

that is

$$\frac{\text{volume of tagged-gas-isotope in the reactor cover gas}}{\text{volume of cover gas}}$$

The calculational results, are shown in Table 2, in which it is assumed that the amount of 27 ml is seeded in a fuel pin for the tag gas.

3. Discussion and Conclusion

From the above results, it can be said that Ne-21 isotope is applicable for tag gas but Ne-20 and Ne-22 are not.

To measure the deviation of the concentration of each isotopes of tagged gas, the mass-spectrometer is suitable for the detector and then the some device of gas chromatographic or other method is necessary for separation of the neon gas from the argon cover gas.

Since it is necessary to use sufficient amount of tag-gasses, consequently the possible reduction of a gap conductance between pellet and cladding must be well considered.

It is estimated that following nuclear reaction, $^{23}Na\ (n,\ \alpha)^{20}F \xrightarrow[10.7\ sec]{\beta} {}^{20}Ne$, in the sodium coolant will increase the amount of Ne-20 (about 140 ml/day) but Ne-21 is easily identified by the mass-spectrometer.

Table II-1. Composition of high purity argon gas

Ar	99.73 (%)
Ne	0.19
He	0.055
Kr	0.012
Xe	0.0009
$O_2 + N_2 + CO + CO_2$	< 0.0006

Table II-2. Results of sensitivity evaluation on Ne isotopes

	volume of tag gas seeded in a pin	volume in reactor cover gas as impurity	S/N-ratio*
Ne-20	27 (ml)	3.8×10^4 (ml)	0.00071
Ne-21	27	1.1×10^2	0.25
Ne-22	27	3.7×10^3	0.0073

* It is assumed that the tag gas seeded in a fuel pin perfectly release into cover gas and is mixed well after fuel failure.