Study on the Hardness of PVC Guide Tube in the Neutron Irradiated Capsules

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1.Introduction

A typical HANARO irradiation material capsule consists of three main parts which are connected to each other: protection tube (5m), guide tube (9.5m) and a capsule's main body. The signal cables (Heaters and thermocouples) are connected to a capsule temperature controlling system through a guide tube and connection box system.[1] The guide tube is made of PVC hose with a metal spring support. It is pressurized by helium gas with the internal pressure of 2kg/㎠ to prevent the reactor coolant infiltrate into a joint of the capsule in the HANARO pool. During an irradiation test, the guide tube stretches longer by the internal pressurization and immersion in water at temperature of 40℃. It grows longer by about 30cm during one cycle of HANARO operation.[2] However, the signal cables of thermo- couples and heaters are maintained as constant length.

In this paper, the changes of hardness values are examined to investigate the possibility for long-term use and recycling.

2. Experiment

As shown in Fig. 1, an instrumented capsule is supported or fixed at 4 points of the capsule main body and protection tube. The capsule is fixed to the reactor structure by the bottom guide assembly of the main body and supported by the upper guide spring at the top of the main body in the flow tube. The guide tube is also connected to a protection tube and junction box.

The hardness was measured for two capsules 10M-01K and 09M-02K recently irradiated to investigate the changes of material properties.

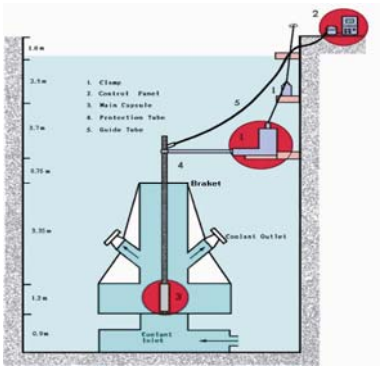

Fig. 1 Schematic view of the instrumented capsule system

The guide tube of capsule is TS-32 model of multipurpose hose type, which is made of soft PVC and fabricated by TOYOX CO. LTD. Japan[3]. The rubber durometer of Mitutoyo HH-336 type A was used for measurement of hardness, which has the standard of ASTM D2240 Durometer A type. This is widely used to measure hardness of soft material such as PVC.[4]

The hardness test was measured at 3 places marked as top-middle-bottom as shown in Fig. 2. The top is the position connected to J/B, and the bottom is that connected to the protection tube. Before the irradiation test, it was measured as shown in Table. 1. After the irradiation test, it was measured at the 3 places. The numbers of measurement are 5 times, respectively.

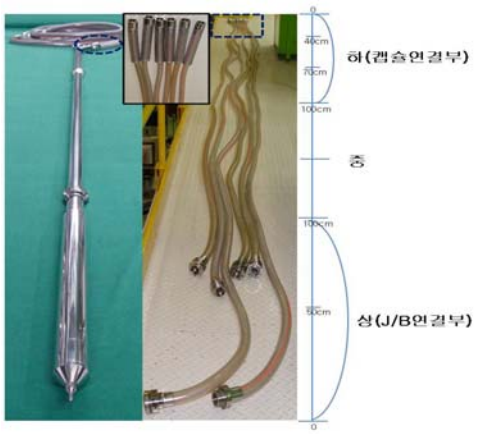

Fig. 2 Positions of measurement in the guide tube

Table. 1 Surface hardness value before irradiation

	Top	Middle	Bottom
1	75.0	74.0	75.0
2	74.0	74.5	74.5
3	74.5	75.0	75.0
Average	74.5	74.5	74.8

3. Results

The 09M-02K capsule was irradiated in the OR5 test hole at 30MW reactor output power for one cycle (about 25.5 days). The irradiation temperature of the specimens was maintained in a range of 250±10℃. A fast neutron fluence of the specimens was obtained in

the range of 1.77~3.76×10^{19}(n/cm^2) (E>1.0MeV). [5]

The 10M-01K capsule was irradiated in the CT test hole of the HANARO of a 30MW reactor output power for one cycle (about 25.5 days). The irradiation temperature of the specimens was maintained in a range of 250±10℃. A fast neutron fluence of the specimens was calculated to the range of 1.37~3.17 ×10^{20} (n/cm^2)(E>1.0MeV) by the MCNP code.[6]

The hardness value of the guide tube after the irradiation test was measured to indicate the average hardness value of 73 shore A. Fig. 3 shows the measured values for the 3 cases of non-irradiated, irradiated of 09M-02 and 10M-01K.

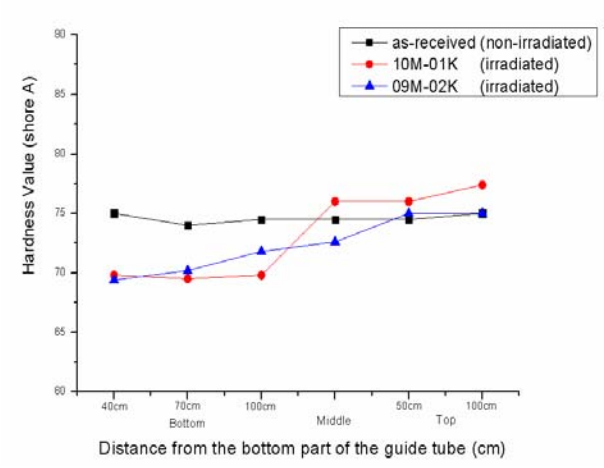

Fig. 3 Hardness value of irradiated guide tube

The measured values for the irradiated guide tube were lower at the 'bottom' position than that of the non-irradiated one. On the contrary, the 'top' position represents higher values comparing with the non-instrumented guide.

To sum up, when comparing the hardness of irradiated and non-irradiated guide tubes, that of the irradiated guide tube are generally lower at the 'bottom' position than that of the non-irradiated. And when comparing that of the irradiated two capsules, the hardness of the capsule irradiated at CT hole is lower than that irradiated at OR5. It means the more softening of the guide tube advances, the more it is irradiated.

With the result obtained from the short-term irradiation, the softening of the guide tube is expected to advance more and trigger breakage for long-term irradiation.

4. Conclusions

The hardness values of the irradiated guide tubes of the 10M-01K, 09M-02K capsules showed the differences of by about 4~7 of shore A between the parts "bottom" and "top" part. These are considered to result from some changes of properties of the guide tube after the irradiation test. This phenomenon may soften the guide tube more and more as the time of irradiation increases and have it break to leak the coolant in when long-term irradiation. It is necessary to execute additional experiments to find detailed causes for changes of material properties of the guide tube during an irradiation test.

ACKNOWLEDGEMENTS

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