Transactions of the Korean Nuclear Society Spring Meeting
Chuncheon, Korea, May 25-26 2006

Design of an Irradiation Tube Assembly for the PTS #1 & #2 at the HANARO Research Reactor

Yong-Sam Chung, Sun-Ha Kim, Jong-Hwa Moon, Byung-Jin Jun and Hark-Rho Kim

Korea Atomic Energy Research Institute, 150 Deokjin-dong, Yuseong-gu, Daejeon 305-353, Korea
yschung@kaeri.re.kr

1. Introduction

Pneumatic transfer system (PTS) of a research reactor is one of the devices for a sample neutron irradiation. A newly designed PTS as one of the facilities to be used in an neutron irradiation of activation analysis has been developed for a re-installation from the end of 2004. The design of a PTS is based on requirements such as the position of the irradiation hole and the geometry of the reactor, the neutron flux and distribution, a gamma heating and temperature at the irradiation place as well as the radiation dose rate, material and type of a rabbit, and the safety of the reactor operation, and so on.

The basic composition consists of six systems as follows; 1) irradiation and transfer system (controller, irradiation tube, transfer tube, auto-loader, loader, receiver, air cushion valve assembly, diverter, photo sensor and a high purity polyethylene or graphite rabbit), 2) N_2 gas supplier system, 3) gas exhaust system, 4) emergency system, 5) shielding system (loader-receiver, receiver, transfer line), 6) DNAA counting system.

In this paper, the newly designed irradiation tube assembly (ITA) of PTS is presented and the results of a safety analysis in the HANARO research reactor are reviewed.

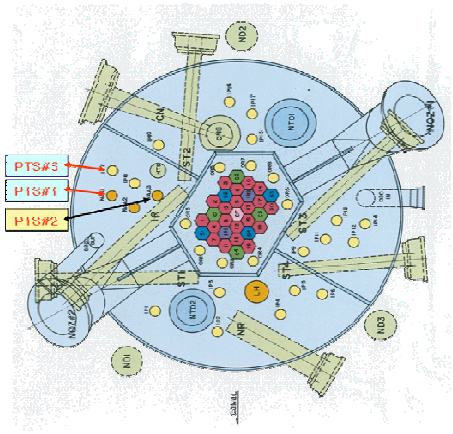

Figure 1. Irradiation holes of three PTS at HANARO research reactor.

2. Instrument and Methods

2.1 Irradiation Holes

These irradiation tubes (IT) of PTS #1 and PTS #2 are to be installed into two irradiation holes (NAA1, NAA2), respectively, in the reflector tank of a reactor as shown Figure 1. The irradiation sites in these systems are located near the reflector by considering the thermalized neutron and flux (about 3E+13 $n \cdot cm^{-2} \cdot s^{-1}$), gamma heating rates (< 1-5 $Watts \cdot g^{-1}$). The ratio of the thermal to epithermal neutron is more than 1000. The diameter of the NAA irradiation hole is 60 mm and the estimated maximum temperature in the irradiation tube under a N_2 gas state is about 50 ℃.

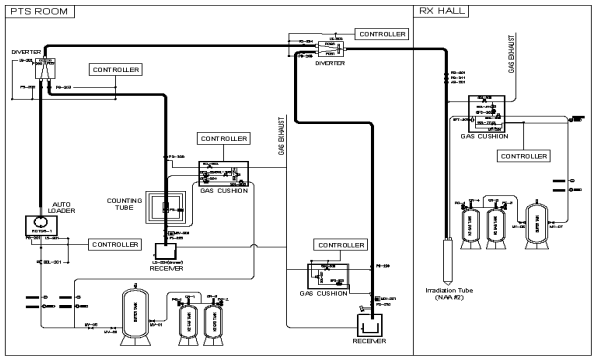

Figure 2. Layout of PTS #2 at HANARO research reactor.

2.2 Fundamental Design

The layout of the new PTS #2 with a delayed neutron counter (DNC) is functionally shown in Figure 2. The irradiation system consists separately of an irradiation tube and an exhaust tube to contact it with the cooling water of the reactor. That is, a pair of IT consist of a rabbit transportation tube with a stopper and a gas pressure tube for a supply and exhaust of N_2 gas between 15 and 25 psig. The gas supplier and exhaust line are located at both the loading and irradiation system in the reactor pressure tank. Total length of the irradiation tube assembly is about 15 m and a part of the IT which is made of aluminum rod is 1.4 m. Total weight of the ITA is about 32 kg and the weight bar is 3.4 kg. All of the irradiation tube material used is Al 6061. The inner diameter of the transportation tube and the gas pressure tube in the IT part are 280 mm and 180 mm, respectively.

The interval between the rabbit and the irradiation tube is about 0.7 mm by considering the radius of the curvature and the diameter of the tubes. Features for an irradiation tube of the PTS #1 and PTS #2 are functionally equivalent. The rabbit in both systems can be manually or automatically placed into either the loader or auto-loader, sent to the irradiation tube for a preset time and returned to either the receiver or delayed neutron counter when the irradiation time elapses.

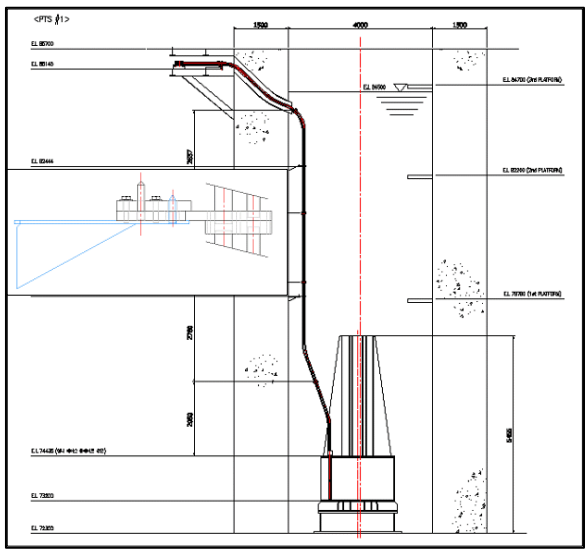

Figure 3. Schematic diagram of irradiation tube assembly in PTS at HANARO research reactor.

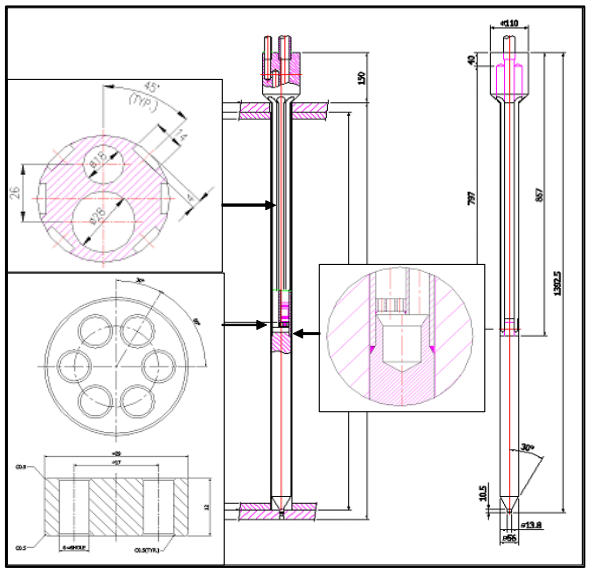

Figure 3. Schematic diagram of irradiation tube in PTS at HANARO research reactor.

2.4 Construction and Test

The irradiation tube assembly will be fabricated and installed by an externally qualified manufacturer according to the protocol of a quality assurance by August 2006. Functional test of the PTS operation will be made with a mock-up before the system is installed, and a rabbit will be filled with a weighted material (about 5g). The inspection and accomplishment of the system shall by carried out by both an expert and a nationally qualified auditing organization.

2.5 Applications

The newly designed PTS will be mainly used for an instrumental neutron activation analysis which contains a delayed neutron activation analysis by using a nuclear fission reaction. In addition, the system will be used for the production of a radioactive tracer, an irradiation test of several materials, a nuclear fission track method, etc.

3. Structural Safety Analysis

For the safety of the irradiation tube assembly of PTS which is indicated as a seismic II class and the reactor operation, a structural safety analysis was carried out. The report for an aseismatic and stress assessment was prepared by using the construction parameters and the design drawing. These considerations imply three categories as follows; 1) the mass of a tube, the pressure of the air and water in the reactor, the seismic and thermal loading and the hydrodynamic mass effect, 2) the homogeneity of the thickness of the irradiation tube, details of the tube welding and flange parts and the radiation effect for a vulcanization of the rubber (NBR) gasket used for a connection of the transfer tube, 3) the evaluation of the tube supporter.

4. Conclusion

The aims of this project were to establish the technology for a new pneumatic transfer system (PTS) design in the HANARO research reactor for an increment of the utilization facility and its effectiveness for an instrumental neutron activation analysis (INAA). The specifications for the construction of the new PTS were prepared to improve the safety of its operation, and the drawing of the system. The results will be used for wider applications for the NAA in many fields by an enlargement of the HANARO utilization facility.

Acknowledgements

This project has been carried out under the nuclear research and development program by the Ministry of Science and Technology, Republic of Korea.

REFERENCES

[1] Y.S.Chung, J.H.Moon, S.H.Kim, Y,C.Park, M.J.Kim, J.S.Yu, Y.K.Cho and H.K.Kim, Development of Pneumatic Transfer System Design in HANARO Reactor for Neutron Activation Analysis, KAERI/RR-2463/2004, 2004.

[2] Y.S.Chung, S.H.Kim, J.H.Moon, and Y.J.Kim, New Design of a Pneumatic Irradiation Facility (PTS #1, 3) at the HANARO Research Reactor, abstracts of Proceedings of the Korean Nuclear Society, Spring Meeting, Jeju, Korea, May 2005.

[3] Manufacturing guide, “Development of pneumatic transfer system of the HANARO reactor”, KAERI/Decon Engineering Corp., Ver. 2, 2005

[4] Corresponding Report, "Estimation of internal temperature for the IP-7 irradiation tube”, HAN-RR-CR-04-016, 2004 ; ‘Calculation of temperature of PTS for NAA”,HAN-RR-CR-05-032, 2005, KAERI.

[5] Technical Report, “Seismic evaluation of pneumatic transfer system of the HANARO reactor”, HAN-PTS-DR-001, Rev.1, KAERI/GNEC, 2006.