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Conceptual Design of the In-pile Plug Assembly and the Primary Shutter for the Cold Neutron Research Facility in HANARO

J. W. Shin, Y. G. Cho, B. S. Seong, S. J. Cho and J. S. Ryu
Korea Atomic Energy Research Institute, 150 Deokjin-dong, Yuseong-gu, Daejeon 305-353, Korea
jwshin@kaeri.re.kr

1. Introduction

The Cold Neutron Research Facility (CNRF) is a facility to produce and utilize cold neutrons for basic science and nano- and bio-technology research. Since 2003, thanks to a national demand for cold neutron research, HANARO (**H**igh-flux **A**dvanced **N**eutron **A**pplication **R**eact**O**r) started a cold neutron research and utilization project [1]. In principle, cold neutrons are generated by passing thermal neutrons through a kind of moderator like liquid hydrogen. Cold neutrons are delivered through neutron guides and reach the scattering instruments to be installed in the cold neutron guide hall located near the reactor building. The neutron guide system is used to focus and polarize the thermal or cold neutron beams from a neutron source to detector positions without neutron losses and with low radiation backgrounds. The neutron guide plays an important role in getting the best performance from the beam experiment.

The neutron guide system of HANARO is divided into three different parts; First, the in-pile plug assembly and the primary shutter with in-plug and in-shutter guides, then neutron guides in the guide shielding room with dedicated secondary shutters, and finally neutron guides connected to neutron scattering instruments in the neutron guide hall.

This paper describes the conceptual design of the in-pile plug assembly and the primary shutter for the neutron guide system at HANARO. Also the design of the guide shielding assembly for the primary shutter and neutron guides is presented at the end of the paper.

2. In-pile plug assembly

The in-pile plug assembly consists of an in-pile plug, a guide cassette and in-plug guides. The in-pile plug with five in-plug guides will be installed in the CN beam port facing the cold neutron source in the reactor side. The CN beam port is a divergent shape with the nose beam size of 70mm x 150mm and the exit beam size of 150mm x 150mm which is located 630mm away from the nose [2]. The in-pile plug is a two-stepped cylinder type with a 380mm (diameter) x 735mm (length) and a 700mm (diameter) x 1170mm (length) as shown in Figure 1. The in-pile plug was designed to install in-plug guides at the exact location in a high radiation environment and to enable an easy maintenance and replacement of the guides periodically. So the in-pile plug includes a guide cassette with a reference frame for an alignment of the guides during an installation and a replacement of the guides.

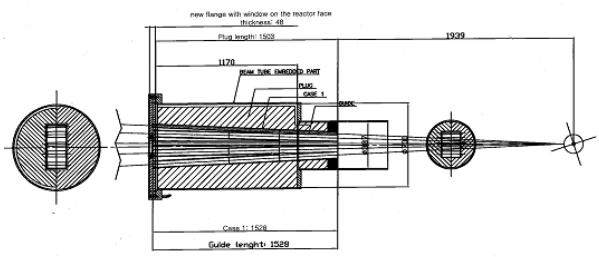

Figure 1. The in-pile plug assembly which includes a in-pile plug, a guide cassette, and five in-plug guides

The in-pile plug with in-plug guides starts in the beam tube embedded part at a distance of 1833mm from the cold neutron source (CNS). Five neutron guides are named as CG1, CG2, CG3, CG4 and CG5 from north to south and they have incline angles of +2.97°, +1.84°, +0.47°, -1.91° and -2.50° with respect to the beam port axis as shown in Figure 2. CG2 and CG5 guides will be separated into two and three guides respectively by using a neutron bender or a splitter next to the primary shutter.

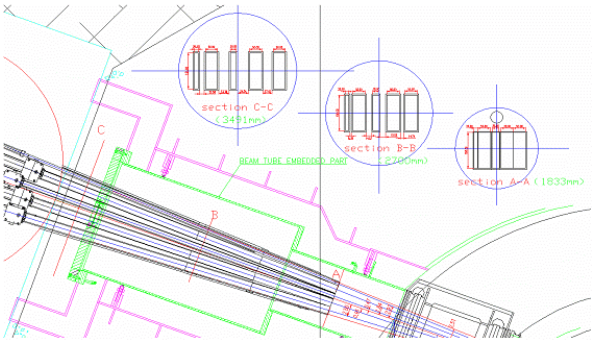

Figure 2. Incline angles with respect to the beam port axis and sections of five in-plug guides

3. Primary shutter

The primary shutter is a mechanical structure to block the beam passage, to be installed just after the in-pile plug assembly at the reactor face. When the shutter is closed, no neutron beams will be available. Five neutron guides are incorporated into the primary shutter and establish a continuity of the neutron guides when the shutter is opened. The primary shutter will be

horizontally rotated by an electrical system using a stepping motor and positioned at the acceptable tolerance level. Figures 3 and 4 show the conceptual designs of the primary shutter to be installed with the in-pile plug assembly.

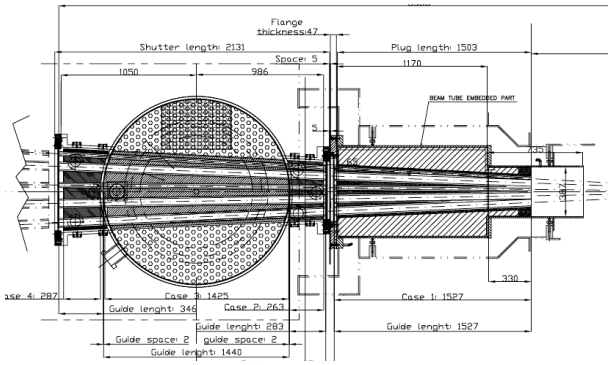

Figure 3. The plan view of the primary shutter and the in-pile plug assembly

For the installation and the maintenance of the primary shutter, it will be installed on a rail system as shown Figure 4 and remotely controlled from control panels in the reactor building. An appropriate interlock system will be provided to ensure a safe operation of the primary shutter. It will prevent an access to the guide shielding assembly when the primary shutter is not fully closed.

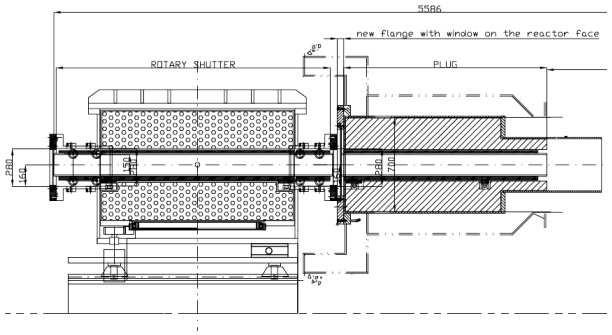

Figure 4. The side view of the primary shutter and the in-pile plug assembly

4. Guide shielding assembly

The guide shielding room (or assembly) is a biologically shielded area surrounding the neutron guides from the primary shutter up to the secondary shutter which is at the end of each guide. It is extended from the reactor hall over a part of the neutron guide hall. Figure 5 shows the guide shielding assembly which surrounds the primary shutter and neutron guides. The guide shielding assembly will be made of concrete blocks whose densities are 4.0g/cc and thicknesses are 500mm. A ceiling and walls of the shielding assembly consists of three blocks respectively, which have shapes of a step at each end. They will be assembled by steel plates and bolts with a gap of 3mm.

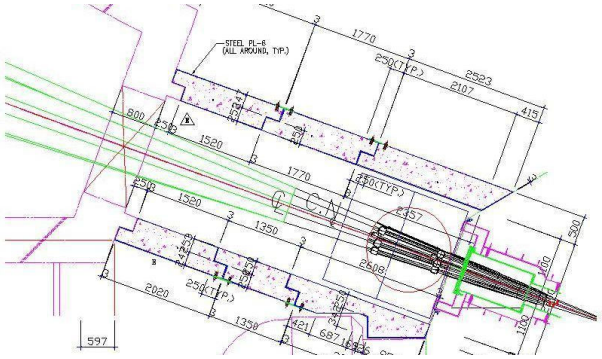

Figure 5. The guide shielding assembly for the primary shutter and neutron guides

5. Conclusion

The neutron guide system is used to focus and polarize the thermal or cold neutron beams from the neutron source to neutron scattering instruments. The neutron guide system will be installed at HANARO to transfer cold neutrons from the cold neutron source (CNS) to the instruments in the neutron guide hall near the reactor building. The conceptual design of the in-pile plug assembly and the primary shutter, which constitute the first part of the neutron guide system, was carried out by KAERI. The in-pile plug assembly consists of an in-pile plug, a guide cassette and in-plug guides. The in-pile plug is a two-stepped cylinder type and includes five in-plug guides with a guide cassette. The primary shutter is horizontally rotated to open and close the beam passages and moves on a rail system for an installation and maintenance. The operation of the primary shutter will be remotely controlled from control panels in the reactor building.

REFERENCES

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[2] B. S. Seong, S. J. Cho, D. G. Whang, C. H, Lee and Y. J. Kim, Basic Concept of the Neutron Guide System at HANARO, International Symposium on Research Reactor and Neutron Science, p. 518-523, 2005.