Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 10-11, 2007

Detail Design of the In-pile Plug Assembly and the Primary Shutter for the Neuron Guide System at HANARO

Jin-Won Shin, Young-Garp Cho, Sang-Jin Cho and Jeong-Soo 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) project was launched in KAERI in July 2003 for the use of cold neutrons in basic science and technical application [1]. Development of the cold neutron source and related systems, the neutron guides and the neutron scattering instruments is to be accomplished by 2010. Cold neutrons will be generated from the cold neutron source (CNS) which is operated with liquid hydrogen at 20K [2]. The neutron guide system will be installed to transport the cold neutrons from a neutron source to scattering instruments in the neutron guide hall near the reactor building without a significant loss of neutrons.

2. Design

The neutron guide system of HANARO consists of the in-pile plug assembly with in-pile guides, the primary shutter with in-shutter guides, the neutron guides in the guide shielding room with secondary shutters, and the neutron guides in the neutron guide hall. In this paper, design requirements and detail designs of the in-pile plug assembly and the primary shutter were described.

2.1 Neutron guide system

The 5 in-pile guides of different cross sections in the in-pile plug assembly start at a distance of 1833mm from the cold neutron source. The guides in the in-pile plug will be incorporated into the primary shutter out side the biological shielding filled with helium. After the primary shutter, the guides start to curve in the reactor confinement building in order to remove the gamma rays and fast neutrons, with each providing different curvatures. Two of the 5 guides will be separated into two and three guides each by using a splitter next to the primary shutter. In the end, there are 8 guides in the guide hall, and each instrument will be supplied with high flux neutrons. The overview of the neutron guide system is shown in Fig. 1.

2.2 In-pile plug assembly

The functions of the in-pile plug are to shield the reactor environment from a nuclear radiation and to support the neutron guides and maintain them precisely oriented. 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 Fig. 2. The four main parts of the in-pile plug assembly are a plug with a front plug, a base table, a guide cassette, and a new flange with a window flange as shown in Fig. 3.

The plug (Fig. 3A) is divided into a lower half cylinder and an upper half cylinder. The lower half cylinder is fixed to the base table, which can slide into the beam hole. Once the guide cassette is mounted in the pyramidal center space of the cylinder, the upper half cylinder is solidly fixed to the lower part. These parts are machined from cast carbon steel. All the carbon steel parts are nickel plated, in order to avoid corrosion. The steel shall contain less than 10 ppm cobalt. The base table (Fig. 3B) supports the plug during a mounting, and in its final position. It has an important function as a mechanical reference by being attached to a ring flange centered to the beam tube axis.

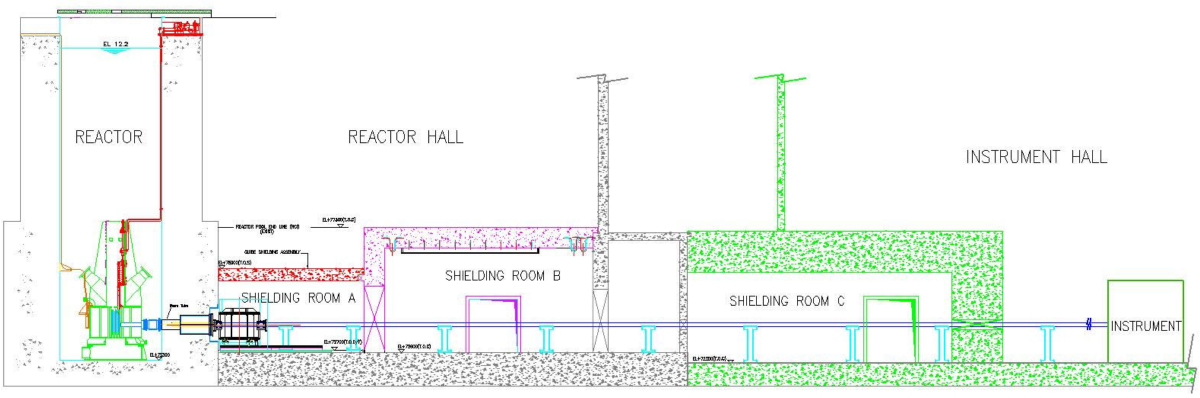

Figure 1. The overview of the neutron guide system including reactor, in-pile plug assembly, primary shutter, neutron guides, guide shielding room and instruments

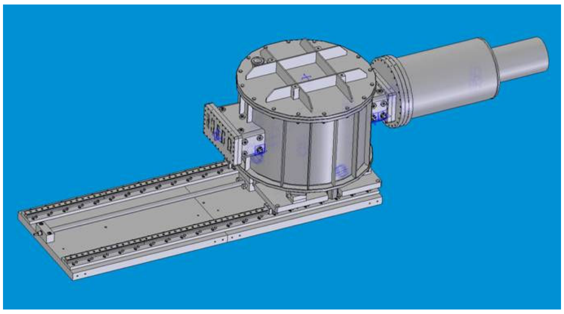

Figure 2. The design of the in-pile plug assembly and the primary shutter

The guide cassette (Fig. 3C) is a steel structure protecting and keeping the 5 neutron guides well aligned to the neutron optical path with several mechanics for a high precision vertical and horizontal alignment. Once the neutron guides are mounted inside the cassette, this assembly is called the optical unit. Typical features of an optical unit are reference markings to reproduce the optical path, and leveling jacks for a height adjustment. These jacks can be remotely operated by special tools.

The new flange (Fig. 3D) is a blind flange, which has the function of keeping the plug in place and confined in a Helium atmosphere. Additional features of the new flange are to transfer the neutron optical axis to the reactor face and to support the cold neutron beam window via a window flange (Fig. 3E). The new flange (diameter 830mm, thickness 50mm) is made of stainless steel 304L and it is fixed to the ring flange with screws M12. The window flange is 30 mm thick and the window is a thin AlMg3 sheet of 1mm thickness.

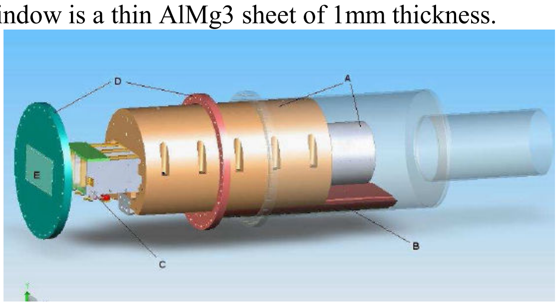

Figure 3. The exploded view of the in-pile plug assembly (A: Plug, B: Base Table, C: Cassette, D: New Flange & Ring Flange, E : Window Flange)

2.3 Primary shutter

The primary shutter is a mechanical device to be installed just after the in-pile plug assembly as shown in Fig. 2, which stops neutron flux on demand. It contains a stainless steel drum (Fig. 4B) that can rotate on its vertical axis to open and close the neutron beam pathway. The drum is housed in a vacuum vessel (Fig. 4A). The neutron guides are located inside the vessel in two static cassettes (upstream and downstream) and one rotating cassette (Fig. 4C). The vessel rests on a support structure with a carriage (Fig. 4D), which can move on rails (Fig. 4E) for an initial mounting, and for access to the beam tube port. A motor drives the drum through a rack-and-pinion gear.

The vacuum vessel holds the neutron guide components in an alignment and under a vacuum. It is a welded structure with an inner diameter of 1450mm and a height of 1000mm, made from a stainless steel sheet of a 20mm thickness. The vessel lid (Fig. 4L) is welded with a flange that fits to the vessel top flange. The vessel base plate is welded to the shroud. It contains the upper side a ring, which holds a heavy precision bearing. The drum can rotate smoothly on this bearing.

The rotating drum is made of lower and upper parts, which envelope the neutron guide rotating cassette. Each part of the drum is a welded cylindrical box made of a 15mm steel sheet, which is filled with a high density concrete and some shielding additives.

The vessel support structure consists of a 100mm thick base plate, two rails on their supports, and a 1.6m x 2.0m carriage with rollers. The primary shutter can be installed on the carriage by the crane 2m downstream from its final position. Once the neutron guide cassettes are aligned, the shutter can be moved precisely parallel to the optical axis towards the reactor face.

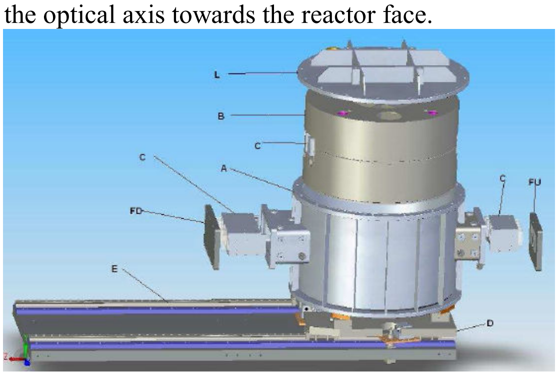

Figure 4. The exploded view of the Primary shutter (A: Vessel, B: Drum, C: Cassettes, D: Carriage, E: Rails, FD: Window downstream, FU: Window upstream, L: Lid)

3. Conclusion

The design of the in-pile plug assembly and the primary shutter for the neutron guide system at HANARO were performed by KAERI and MTF GmbH. The in-pile plug assembly and the primary shutter shall be fabricated by domestic companies according to these designs and technical specifications by the end of April 2008.

REFERENCES

[1] Y. J. Kim, et al, Conceptual Design of the Cold Neutron Research Facility in HANARO, HAN-CP-RD-030-04-001, p170-181, KAERI, 2004.

[2] K. H. Lee, Y.J. Kim, Proceeding of the international symposium on research reactor and neutron science, p537-539, HANARO 2005.