Torque Audit and Visual Inspection of the In-Pool Assembly for CNS in HANARO

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1. Introduction

The Cold Neutron Source (CNS) was installed at the HANARO in 2009 and has been operated over 2 years to supply cold neutrons for the cold neutron scattering instruments. The liquid hydrogen, which is cooled down to 152$\pm$3 kPa(a) by the helium refrigeration system, in the moderator cell of In-Pool Assembly (IPA) is used to moderate thermal neutrons into cold neutrons [1]. Cold neutron flux is dependent upon the state of liquid hydrogen, which can be identified by the pressure. So the operation of the helium refrigeration system is most important to keep the hydrogen pressure stable. Another factor influencing cold neutron flux is the thickness of the water film gap between the outer surface of IPA and the inner surface of CN vertical hole [2]. The IPA was installed in the CN vertical hole closely to the CN beam tube within a minimum water film gap to get maximum cold neutron flux. But if tightening bolts assembling the IPA on the reactor structure become loose in abnormal cases, the water film gap could be changed and therefore influence cold neutron flux. So we need to check the installation torques and to inspect the assembly status of the IPA on the reactor structure to ensure that the water film gap is kept well as initially installed. This paper presents the results of the torque audit and the visual inspection of the IPA performed in 2011.

2. Methods and Results

2.1Inspection Scope

The IPA is assembled on the reactor structure by tightening bolts of the vacuum chamber flange on the joint flange of CN vertical hole as shown in Fig. 1. It is also supported by pins of the fixing bracket which is bolted on the chimney of the reactor structure. The specification of the tightening torque is of crucial importance in determining the reliability of the joint. So the torque audit is needed for checking screw bolts 2EA of fixing bracket and 3EA of vacuum chamber flange as shown in Fig. 2. In addition the visual inspection of the IPA on the reactor structure is also necessary for checking any displacements which can influence the water film gap. The inspection items of IPA are as follows.

- Gap between vacuum chamber assembly and chimney
- Gap between fixing bracket and chimney
- Supporting pins in fixing bracket
- Gap between joint bracket and fixing bracket
- Tightening bolts of joint bracket
- Gap between vacuum chamber flange and joint flange
- Welding parts of flexible double pipes
- U clamping bolts of flexible double pipes

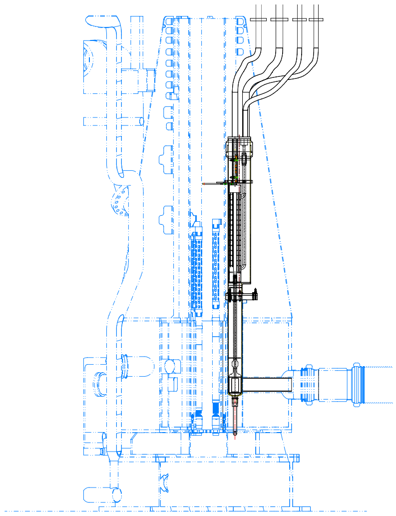
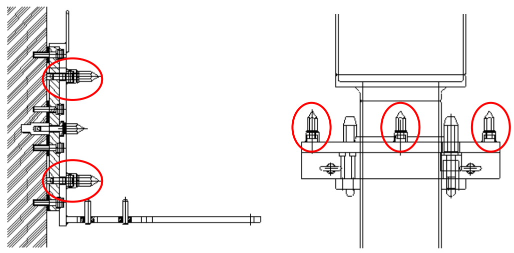


Fig. 1. Side view of the in-pool assembly installed at CN vertical hole of the reactor vessel.



(a) Fixing bracket (b) Vacuum chamber flange
Fig. 2. Torque audit items for the IPA

2.2 Inspection tools

A torque wrench was used to audit the specified torques to the screw bolts fixing the IPA on the reactor structure (Fig. 3-a). A remotely controllable underwater camera was used for the visual inspection of the IPA status. It is a high radiation tolerant camera, and can be controlled and monitored at the top of the reactor pool (Fig. 3-b).

(a) Torque wrench (b) Underwater camera
Fig. 3. Inspection tools

2.3 Inspection procedure

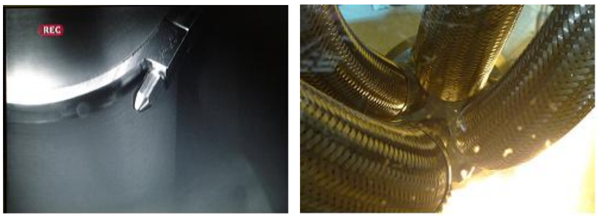
A procedure for the torque audit and visual inspection of the IPA was made to examine the assembly status of the IPA [3]. It includes inspection items, conditions, procedures, and criteria for judgment. Especially a resolution test of the underwater camera using an 18% grey card with a fine line 0.8mm in width was performed before and after the inspection according to article 9 in ASME SEC. V, "Visual Examination" [4].

2.4 Results

The specified torques to tighten screw bolts of the fixing bracket to the chimney and the vacuum chamber flange to the joint flange are both 450 kgf·cm. The torque audit was implemented using special long tools and the torque wrench which was calibrated and certified by Korea Testing Laboratory. It showed that all screw bolts were tightened conforming to the torque specification. The visual inspection also showed that there were no remarkable displacements of the IPA which could influence the water film gap. The joint bracket of the vacuum chamber was supported by two pins of the fixing bracket, and the gap between two brackets was the same as that of the installation stage (Fig. 4 - a, b). The vacuum chamber flange was completely tightened to the joint flange of the CN vertical hole so that there was no gap between two flanges (Fig. 4 - c, d). The joint bracket of the vacuum chamber was clamped well with the tightening bolts (Fig. 4 - e). There were also no defects at the welding surface of flexible double pipes (Fig. 4 - f).

(a) Supporting pins of the fixing bracket (b) Joint bracket supported on fixing bracket

(c) Vacuum chamber flange bolted on the joint flange (d) Vacuum chamber flange



(e) Joint bracket (f) Flexible double pipes
Fig. 4. Results of the visual inspection of the IPA

3. Conclusions

In order to examine the assembly status of the IPA for CNS in HANARO, the torque audit and visual inspection was performed in August 2011. It is important to check out the mechanical and structural status of the IPA because any physical displacement of the IPA can influence cold neutron flux by changing the water film gap. The results showed that there were no loosening of tightening bolts, change of gaps between parts, and defects on the welding surface of flexible pipes.

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