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Improvement on the Blind Flange of a Fuel Transfer Tube

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1. Introduction

A blind flange installed at the end of the fuel transfer tube in a reactor building is a passageway to transfer the fuel assembly between the reactor and the spent fuel pool in nuclear power plants.

It shall be closed to accomplish a pressure boundary during the power operation of the reactor, and removed prior to refueling operation. It is installed in a high radiation area, called sometimes “hot spot”, and shall be unbolted to be removed by the operator. In order to reduce working time for installing and removing it, alternative method is required.

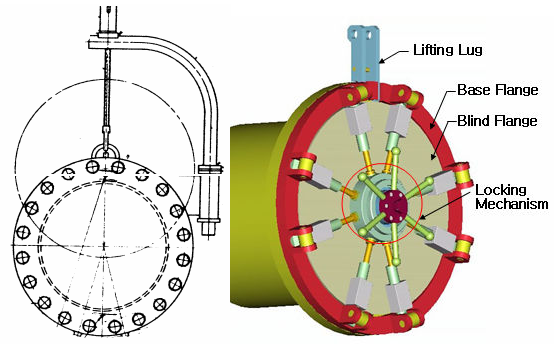
This paper introduces the blind flange of the fuel transfer tube which has an improved locking mechanism, and describes its design features, structural integrity, and the improvement effects.

2. Design Features

2.1 Component Description

The existing blind flange was connected to the fuel transfer tube with 20 bolts prior to its removal. The complex assembly requires a lot of working time to assemble and disassemble it in the high radiation area. As a result, The worker is liable to be exposed to high irradiation.

To improve the workability, a new design of the blind flange of the fuel transfer tube is suggested and shown in Figure 1 (b).



(a) (b)

Figure 1. Comparison of existing (a) and improved (b) blind flange.

The improved blind flange consists of an annular flange, a modified blind flange, a locking mechanism and sealing media.

The annular flange has eight(8) locking guidance mechanisms to fix the modified blind flange and is bolted to the mating flange which is welded to the fuel transfer tube. The modified blind flange consists of six(6) branch hand levers, two(2) seal rings for a leak test, and a positive locking device and eight(8) locking mechanisms.

The modified blind flange is installed on the surface of the mating flange and in the annular flange by the turning hand lever, and keeps pressure boundary by the eight locking mechanisms. Once the modified blind flange was installed, the positive locking devices prevent the locking mechanisms from being released all the time. The installation is completed by the air leak test to confirm the pressure boundary. When the modified blind flange is removed, the positive locking device is released, and then the branch hand lever is operating.

2.2 Review of Design Requirements

The design of the improved blind flange assembly is performed on the basis of the Final Safety Analysis Report[1] and technical manual[2] for the fuel transfer tube for Yonggwang Units 1&2. The design data not available in the existing documents have been collected from measuring the dimension of the mating and existing blind mating flange. Some design data are gathered from those documents of the Optimized Power Reactor (OPR1000) by conservative estimation.

The blind flange of a fuel transfer tube plays a role in containment pressure boundary during the power operation of nuclear power plants, which prevents a radioactivity material leakage. It is classified as safety class 2 according to ASME code 51.1[3] and shall be designed to a Seismic category I and to apply Subsec. NE of ASME Sec. III, “metal containment”. The applicable code date for the design is defined in Article 13 of MOST Notice 2004-13 "Regulation about an examination of the operation of nuclear reactor equipment"[4].

Improved blind flange was designed considering the interfaces between the fuel transfer system and the adjacent structures during design stage.

During the fabrication of the improved blind flange assembly, materials satisfy the requirements, shall have the certification mark according to the ASME code[5], and are suitable for refueling water and radiation exposure. Pressure retaining parts shall be fabricated in

accordance with the ASME code[5] as well. positive locking mechanism should not be opened by an earthquake.

After the fabrication of the improved blind flange assembly, it should have both a hydrostatic test and a pneumatic test in accordance with NE-6000 of Reference [5].

3. Evaluation of the Improved Blind Flange Assembly

3.1 Structural Integrity

Components of the improved blind flange assembly were evaluated for stresses in accordance with the design condition of design loads shown on Figure 2. The Structural integrity of the improved blind flange assembly are satisfied with the specified level of Subsection NE of Reference [5]. The guide pin attached to the annular flange indicates to have the highest stress level.

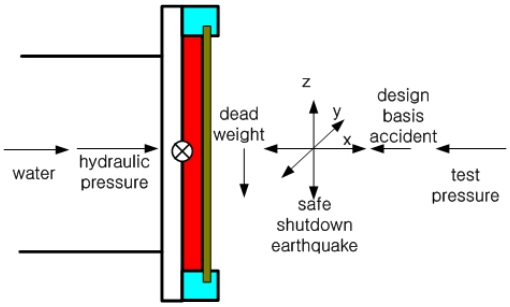


Figure 2. Design loads

3.2 Reduction of the working time & radiation exposure

The improved blind flange assembly is estimated to reduce approximately 70% of working time for removal and installation as shown in Table 1. As reduction of the man-power through work simplification, the radiation exposure of the operator can be decreased by about 70%.

Table 1. Effects for apply improved blind flange assembly

Description	Existing	Improved	Improvement
Working Time (min.)	70	20	50
Workers (man)	4	2	2
Radiation (Man-mSv)	1.0	0.3	0.7

4. Concluding Remarks

The improved blind flange assembly of the Yonggwang Units 1&2 has been developed for replacing the existing blind flange supplied by Westinghouse Co. during plant construction.

Design requirements, interface requirements, manufacturing requirements, test requirements and an essential environment factor were reviewed and evaluated during the design stage. Structural integrity the improved blind flange assembly was confirmed.

When the improved blind flange assembly is applied to nuclear power plants, it is expected that the working time can be shortened by about 50 minutes and the subsequent radiation exposure is decreased by about 0.7 mSv.

REFERENCES

[1] Final Safety Analysis Report for YGN 1&2
[2] Technical Manual for Fuel Transfer System for YGN 1&2
[3] ANSI/ANS-51.1, Nuclear Safety Criteria for the Design of Stationary PWR Plants, 1983 (Reaffirmed, 1988).
[4] Article 13 of MOST Notice 2004-13 "Regulation about an examination of the operation of nuclear reactor equipment".
[5] ASME Sec. III, Division 1, Subsec. NE, Class MC Components, 1977.
[6] Improvement on Fuel Transfer Tube Blind Flange for Yonggwang Units 1&2, Dec. 2004.
[7] Development of Technology for Engineering Service of Nuclear Power Plant in Operation, Mar. 2002.