
Disassembly and Visual Inspection of CANDU Modified 37-element Bundle

S.K. Woo^{1*}, M.J. Kim¹, H.S. Kim²

¹KEPCO Nuclear Fuel, 493 Duckjin-Dong, Yuseong-Ku, Daejeon 305-353, skwoo@knfc.co.kr

²Korea Hydraulic & Nuclear Co., 260 Naah-ri Yangnam-myun, Kyeongju, Kyoung-buk, 780-715

ABSTRACT: *It is known, CANDU (Canadian Deuterium Uranium) type fuel bundle is not designed to be disassembled like PWR fuel assembly. For this reason, the visual inspection has been performed only for the outer surface of the spent fuel bundle. To verify the integrity of CANDU modified 37-element bundle (37M), the visual inspection for inner elements is essential. Some special disassembly tools and method have been developed for the inner element visual inspection. Some regular 37-element bundle (37R) was selected for comparison with 37M inspection result. The disassembly and visual inspection of element for 37M and 37R were performed with using the tools which KNF had developed at Wolsong NPP unit 4. This paper introduces performance experience and the result of the bundle disassembly and the visual inspection of element at Wolsong NPP unit 4.*

KEYWORDS: *37M, 37R, Bundle Disassembly, Visual Inspection of Element*

I. INTRODUCTION

For the CANDU modified 37-element bundle (37M) licensing in Korea, it is required to perform a burnup performance test and visual inspection as a follow-up test. The burnup performance test for four bundles has been previously conducted at Wolsong NPP unit 4.

To perform the visual inspection inside an irradiated fuel bundle, the bundle disassembly is necessary. In case of CANDU type, end plate and end plug are connected by welding so the bundle disassembly is impossible in the usual way: visual inspection only for outer elements has been made so far. Since the main change for 37M is about center element modification, it is important to verify its integrity by the visual inspection for the inner elements and comparison with *regular 37-element bundle (37R)*.

For this reason, KNF has developed the disassembly tools and method. Disassembly tools have been tested in the KNF's facility, and the desired elements for the

bundle disassembly and the visual inspection of element were selected in advance.

The bundle disassembly and the visual inspection of element for 37M and 37R were completed successfully, and the integrity of 37M including the center element was confirmed.

II. BUNDLE DISASSEMBLY TECHNIQUE

II.A. Development of Bundle Disassembly Tool

As 37M fuel was developed, it has been loaded at Wolsong NPP unit 4 as a demonstration. After the fuel bundle was burned up, it was required to disassemble the fuel bundle and conduct visual inspection for the central element and other inner elements.

Since 37M and 37R fuel bundles are assembled with welding, it is technically difficult to be disassembled. The existing visual inspection equipment is only possible to check the outer surface of the fuel bundle.

In case that inspection for the inner parts of bundles are requested, it is impossible to perform with the existing equipment. It has been asked to develop the bundle disassembly tool and the visual inspection equipment to confirm the inner elements of bundles.

KNF examined the 37M fuel bundle structure, applicability for Korean sites, safety issue and etc. Since the spent nuclear fuel is a high radiation material, this all process is conducted in water with long handling tool from out of water. Based on the examination result, KNF has improved the existing equipment and invented new tools. Some bundle disassembly tools (including long handling tool) are introduced from Stern Lab in Canada. The bundle disassembly tool set consists of the long handling tool and other 9 type tools, and the visual inspection equipment set consists of the underwater color camera, the bundle rotator and the element rotator. Other peripheral tools are the element storage racks for 37M and 37R, the scrap basket for collecting scraps and etc.

II.B. BUNDLE DISASSEMBLY

All equipments are arranged under approximately 5 m of water on the bottom of the pool. Some tools are chosen and exchanged during the bundle disassembly process as occasion demands (Fig. 1). The disassembly is conducted with the underwater color camera for monitoring and 6 m long handling tool from the work platform installed above the pool. Two trained personnel performed bundle disassembly with the bundle disassembly tool on the work platform, and other two personnel controlled the camera, check process and record details on papers.

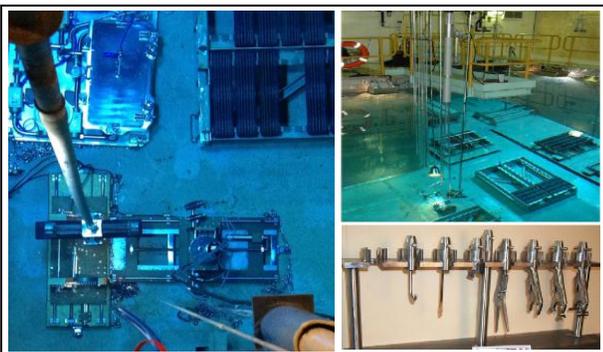


Fig. 1. Bundle Disassembly Equipment

The bundle disassembly is conducted with using a bundle rotator and a screwdriver type pry tool. The blade of the pry tool needs to be placed between the end cap and endplate nearest the element to be removed. With using a twisting motion on the tool handle, the end cap-to-endplate weld of the desired element becomes separated. Once the end of the element has been disassembled free, it is performed again on opposite side of the element.

After the desired element has been disassembled, it is temporarily carried to the element storage rack with an element gripper (Fig. 2). A scrap basket and a bundle holding tool are also used for safety.

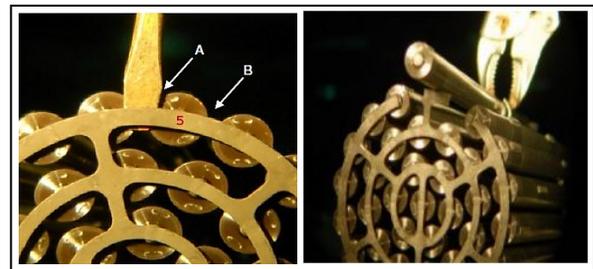


Fig. 2. Element Disassembly and Transfer with Pry Tool and Element Gripper

The number of desired elements for the bundle disassembly is nineteen among thirty-seven elements (Fig. 3). Each of 37M & 37R elements should be stored in a separate element storage.

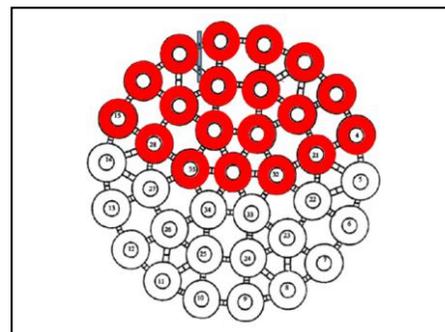


Fig. 3. Map of Desired Elements for Disassembly

Once the disassembly is completed, all elements left in the bundle were tied up with Stainless Steel (STS) wires and stored in the facility.

III. VISUAL INSPECTION OF ELEMENT

The major change of 37M form 37R is central element dimension modification. It is expected that the central element dimension change has an influence on other peripheral elements under burnup condition. Therefore, the integrity confirmation on the central and peripheral elements is required. The result of bundle disassembly and visual inspection of demonstration fuel bundle 37M & 37R will be used in 37M licensing report.

Visual inspection equipment consists of the element rotator, underwater camera, and video recorder. Once all desired elements have been removed from the bundle and stored on the storage rack, the elements can then be individually moved to the element rotator and inspected with using the underwater camera and the video recorder.

The number of desired elements for the visual inspection is seven among nineteen separated elements (Fig. 4). The inspection items are physical deformation, surface discoloration, signs of fission gas leak, wear, physical damage of the end plug, weld defect and signs of wear or corrosion.

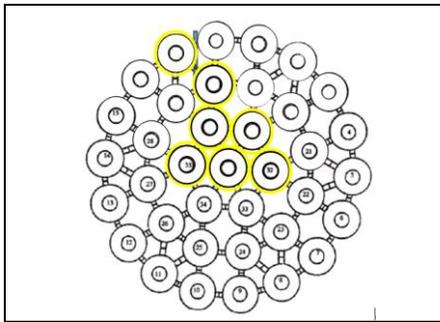


Fig. 4. Map of Desired Elements for Visual Inspection

Visual Inspection on fuel elements is conducted with rotating the desired elements for three angles (120°, 240°, 360°) (Fig. 5). The inspection is recorded, and any unusual features on the elements are noted.

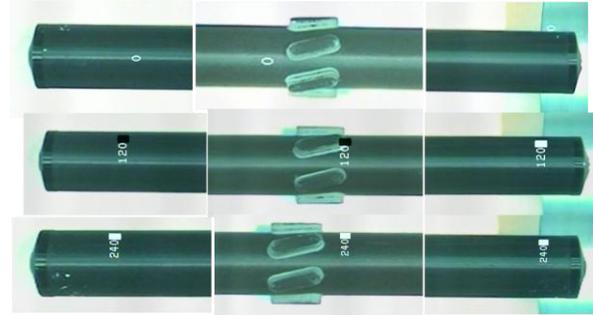


Fig. 5. Visual Inspection using Three Rotation Angles

IV. RESULT AND DISCUSSION

Each one of the 37M and 37R fuel bundles was selected and disassembled at Wolsong NPP unit 4. The nineteen elements of each fuel bundle were successfully disassembled. The bundle residues are tied up and carried to the rack in the facility.

The visual inspection for the fourteen elements of 37M and 37R was completed.

Especially, because of the central element dimension modification, it is inspected closely.

As a result, integrities of both bundle types were confirmed without any critical issue.

The disassembly equipment that has been developed by KNF was used for 37M & 37R fuel disassembly, and its performance and stability were verified.

TABLE I. Inspection Result

Inspection Item	Details	Result
Element	Physical deformation, surface discoloration, signs of fission gas leak, physical damage	Accepted
End plug	Tear, weld crack	Accepted
Bundle Structure	Wear, Corrosion mark	Accepted
Space pad	Wear, Corrosion mark	Accepted

V. CONCLUSIONS

Each one of 37M and 37R fuel bundles was selected and disassembled at Wolsong *NPP* unit 4. The nineteen elements of each fuel bundle were successfully disassembled.

The visual inspection for the fourteen elements of 37M and 37R was completed. As a result, integrity of both bundle type were confirmed without any critical issue.

Disassembly equipment that has been developed by KNF was used for 37M & 37R fuel disassembly, and its performance and stability were verified.

REFERENCES

1. B. Simons, "TRAINING DOCUMENT," Stern Labs SLTD-008, (2015).
2. Q. Jacobs, "37-Element CANDU fuel bundle Element Disassembly Guidelines," AMEC Foster Wheeler SB002/RE/001 R000, (2015).
3. M.J. Kim, "Disassembly and Visual Inspection Report for Modified CANDU Type Fuel Bundle," *FSR-16-W4-133*, (2016).
4. M.J. Kim, "Disassembly Procedure for CANDU Type Spent Fuel Bundle," *SP-20-18*, (2015).