

## In-Bay Visual Examinations of Post-Irradiated CANDU Fuel Bundle

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### 1. Introduction

This paper intends to provide the results of the visual examination of post-irradiated (PI) CANDU fuel bundle [1]. Accompanying the in-bay dimensional measurements of eight PI bundles [2], the visual examination of each part of fuel bundle is performed in spent fuel reception bay of Wolsong-3 reactor by the underwater camera (R981 model) of the measurement system [3]. Eight test bundles had been located at the 11<sup>th</sup> and the 12<sup>th</sup> bundle positions of four fuel channels as shown in Table 1. Based on the plant operating data for 17 months, it is shown that the high power channels (G-13, Q15, O-07) and the low power channel (D-06) are included in the most probable two-phase flow channels [4]. So, it can be regarded that these bundles irradiated at two-phase flow region and suffered power ramp (i.e., in the 3<sup>rd</sup>/4<sup>th</sup> bundle positions and then in the 11<sup>th</sup>/12<sup>th</sup> bundle positions). The major points of the visual examination are the followings ; Is there any cracks in the endplates due to a refueling or a cross-flow impact ? ; Is there any signs of excessive spacer fretting ? ; Is there any wears or scratches on the surfaces of bearing pads and outer fuel elements ? ; Is there any significant element bowing ?

Table 1. Information of PI Bundles

Channel	the 11 <sup>th</sup> Bundle	the 12 <sup>th</sup> Bundle	Power (kW)	Flow (kg/s)
G-13	B215201	B215194	6767	25.67
Q-15	B215095	B215094	6721	26.12
O-07	B206773	B206772	6574	25.73
D-06	B211192	B211191	4840	17.71

### 2. Inspection procedure

The visual examination can be performed independently of the dimensional measurements

by using the underwater camera of the measurement system installed in spent fuel reception bay (Figure 1). The camera system has the functions of x-y direction moving, panning and tilting as well as zooming. Before installing the bundle on the system, the camera is focused on the front surface of endplate with lifting the bundle by C-clamping tool [1] to check the serial number of bundle ("K" is only marked on one of endplates). On the first inspection during the dimensional measurements, a close inspection is repeated by the following procedures ; moving the camera near the end of bundle, focusing on the mirror installed at the corners of the system to view the front of endplate, examining the surface of endplate, moving the camera back at 1/4 plane, focusing on the bundle (including the endcap and the bearing pad), examining the surface of elements and bearing pads by slowly rotating bundle, and repeatedly examining the surface of elements and bearing pads at mid-spacer and 3/4 planes. A precise control of panning and zooming is needed to obtain the clear view. All inspection data saves on video tapes.

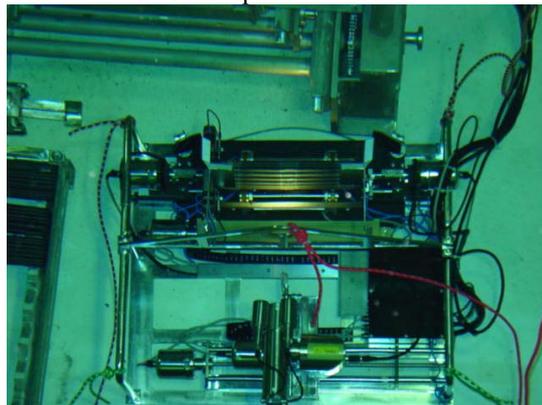


Fig.1 Measurement System in Reception Bay

### 3. Results and discussion

Figure 2 examines the front view of endplate to find out any cracks which may be caused by a impact or a long period residence in the cross

flow during refueling. This view can read the serial number of bundle and K mark on the endplate. There is no evidence of cracks or local deformation on the endplates of eight PI bundles.

Figure 3 focuses on the surface of elements (including bearing pads) at the mid-spacer plane of bundle. All the surfaces of 18 outer rods can be examined by slowly rotating bundle. Some minor wears or scratches appear on the surfaces of bearing pads and elements for bundles in high power channel (O-07). But, most of rod surfaces look clean. Excessive spacer fretting will appear as “notches” between spacers. It is difficult to find out any signs of excessive spacer fretting by focusing the camera at the mid-spacer plane of bundle. Rods may be bowed radially outwards/inwards or be S-shaped by experiencing the non-uniform conditions of coolant temperature, heat generation and axial loading in a rod. During the visual inspection, most of elements look fine but the definitely bowed rods appear on bundles in high power channel (O-07 and Q-15). A slight bowing (less than 0.50 mm) appears on even the fresh bundles [5]. So, it is difficult to determine in-bay visually how much bowing happens on the PI bundle. Based on the results of the dimensional measurements [2], the maximum bowing and the bowed rods are summarized in Table 2. Some significant bowing (1.2mm~2.5mm) appear on the several elements of O-07 channel bundles. But, the S-shaped bowing does not happen.

#### ACKNOWLEDGEMENTS

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Table 2. Outer Rod Bowing of PI Bundles

Channel	Max. Bowing (the 11 <sup>th</sup> ,mm)	Bowed Rods (the 11 <sup>th</sup> )	Max. Bowing (the 12 <sup>th</sup> ,mm)	Bowed Rods (the 12 <sup>th</sup> )
G-13	0.8	13,14	0.9	7,8
Q-15	1.0	17,7	1.1	16,10, 14
O-07	2.5	12,9,1,3,10	1.2	14,8,17,11
D-06	-0.5	11,7	0.4	11



Fig.2 Examination of Surface on Endplate

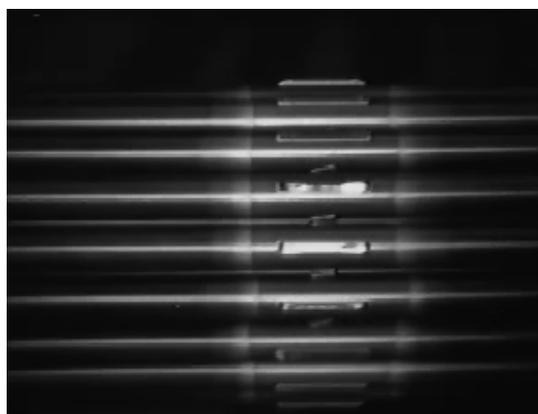


Fig.3 View of Mid-Spacer Plane of Bundle

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