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Status and Plans of Burst Test on Wolsong Unit 2 Pressure Tube

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1. Introduction

A pressure tube (PT) is a main structure of the heavy-water reactor that affect the reactor safety. Therefore the integrity evaluation of the pressure tube is necessary for the reactor safety.

In CANADA, the pressure tube material surveillance (PTS) is a mandatory program under CSA N285.4 Section 12 [1]. The surveillance test results are compared to both historical surveillance data and predictive models to ensure the material is aging within known parameters. In addition, optimizing the lifetime of the PT is possible by analyzing the accumulated PTS data and it means that the life time of the reactor is potentially able to increase.

The pressure tube are operated to satisfy a leak-before-break (LBB) criterion. Based on the LBB criterion, if an undetected flaw grows across and along the tube, it have to produce leakage of coolant detection before growing to a critical crack length (CCL) [2]. The CCL is closely related to fracture toughness. The fracture toughness is an important data for evaluating the integrity of the PT and can be obtained by a burst test and a curved compact tension (CCT) test. In case of the burst test, there is an advantage that the fracture toughness can be obtained by simulating under the more realistic conditions than CCT test. However, repeated tests are difficult because large amount of materials are needed. Therefore, the burst test data of the irradiated PT is especially valuable.

Surveillance tests of Wolsong Unit 2 pressure tubes will be performed in IMEF for safety analysis. In this study, status and plans of the burst test on Wolsong Unit 2 pressure tube are introduced.

2. Methods

2.1 Cutting plan and specimen preparation for burst test

Mechanical properties of PT are determined as a function of fluence and temperature. As shown in Fig.1, the temperature increase with going from the inlet region to the outlet region. In addition, it has high-fluence at the centre region of the PT. The burst test specimen is selected to be at the expected peak damage location, (i.e. inlet side of centre). The inlet side of centre have intermediate temperature and high fluence.

Preliminary underwater cutting will be performed at Wolsong service bay using a saw. Based on the planned cutting plan, about 70cm long PT will be cut for the

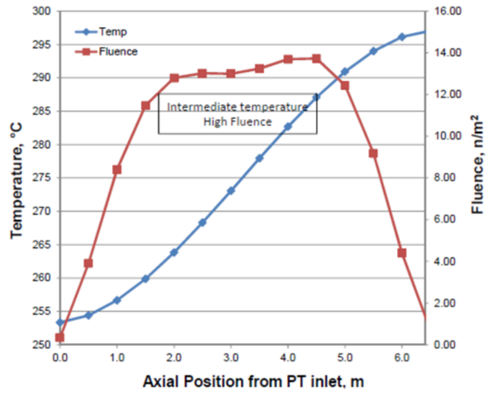

Fig.1 Fluence and temperature according to axial position from PT inlet

burst test. The burst test specimen will be shipped from Wolsong to IMEF using type B cask. After moving into the hot cell, a lathe will be used to trim and square the ends of the burst test specimen to a final test length of 50cm. In addition, small fracture toughness and tensile strength specimens will be obtained adjacent to the inlet and outlet to the burst test specimen.

Finally, the oxide in and out side of the burst test specimen will be removed to attach a potential drop measurement equipment. The potential drop technique is used to measure the propagation of the crack.

2.2 Burst test procedure

The burst test procedure is composed of five parts:

1. Machining a starter notch using a portable EDM
2. Installation of a patch over the flaw
3. Fatigue cycling to crack sharp flaw tips
4. Pressurization to failure

First, an axial, through-wall notch (about 45mm length) are machined using the portable EDM. The notch are sealed using a patch and the potential drop measurement equipment is attached to the burst test specimen. There are a linear relationship between the change in voltage and change in crack length. Each section is sealed with end caps and attaches to the pressurizing system. Before the testing, the axial notch is extended at crack tip by fatigue pressure cycling. Finally, the burst test specimen is pressurized with argon gas to failure. After the burst test, the EDM would be used to remove the burst test fracture face. In addition, digital images of the fracture face shall be obtained and shall be used to measure the fatigue crack length and characterize the crack growth behaviour burst testing.

2.3 Burst test system

Fig.2 shows the burst test system layout. The burst test system is composed of five major components :

1. Burst test equipment and bell jar
2. Pressure Intensifier
3. Hydraulic Pump
4. Chiller
5. Controller

A hydraulic pump, a pressure intensifier, a chiller, and a controller will be installed in operating area for the fatigue cycling. The DI water line, power line and signal line will be connected with the burst test equipment through the penetration hole installed under the working table. Fig.3 shows the burst test equipment and bell jar. As shown in Fig.4, the burst test equipment and bell jar will be installed at the first window side of M1 hot cell considering the position of other equipment. The bell jar is designed to prevent the damage due to pressure relief. In addition, support legs will be installed to prevent that a stress wave affects other equipment such as a X-ray CT system.

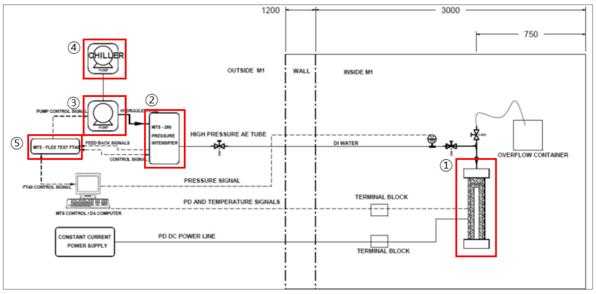

Fig.2 Burst test system layout installed in M1 hot cell and operating area.

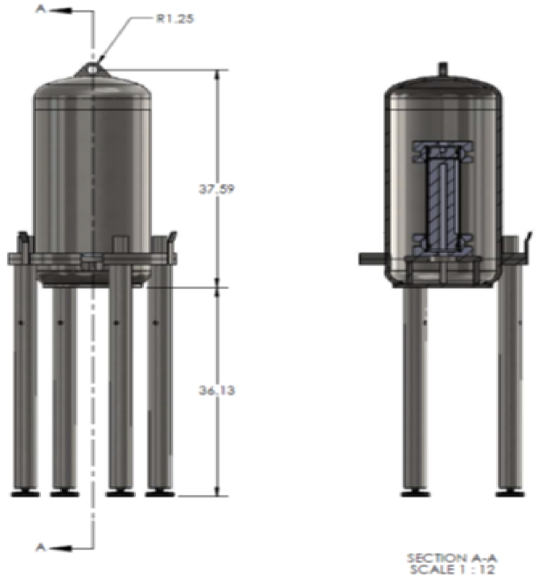

Fig.3 Burst test equipment and bell jar

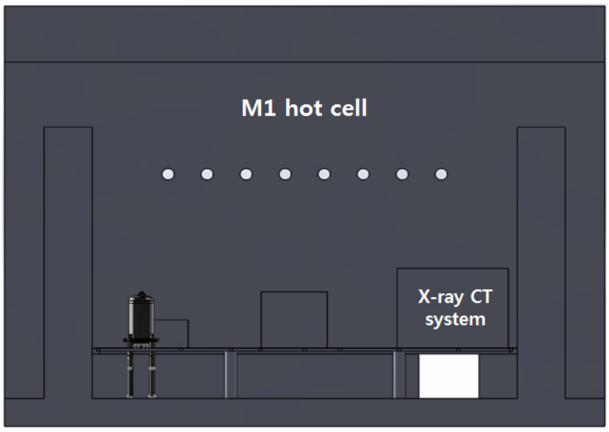

Fig.4 Installation position of burst test equipment in M1 hot cell.

3. Conclusions

Surveillance tests of Wolsong Unit 2 pressure tubes will be performed in IMEF for safety analysis. This project is being carried out with Kinectrics which has test technique and experience. The burst test that is one of the surveillance test item will be performed and we will be able to obtain the fracture toughness data of the irradiated PT which is important in terms of LBB. The test procedure of the burst test was established. In addition, the burst test equipment is being improved to fit IMEF facility. Through the collaboration with Kinectrics, the equipment necessary for PTS will be developed. In addition, it is expected that PTS technique will be localization through this project.

REFERENCES

[1] "Periodic Inspection of CANDU Nuclear Power Plants Components", A National Standard of Canada, CSA N285.4-14, May 2014.

[2] Davies,P.H and Shewfelt, R.S.W., "Link Between Results of Small- and Large-Scale Toughness Tests on Irradiated Zr-2.5Nb Pressure Tube Material," Zirconium in the Nuclear Industry : Eleventh International Symposium, ASTM STP 1295, 1996, pp.492-517.