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# Assessment of Mismatch at Indicated Level of the Upper Side Zone of LZC on abnormal operations

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## 1. Introduction

Liquid Zone Control System of CANDU reactor provides bulk and spatial control. This system has produced abnormal operations with water level increase due to refueling since 1998. The abnormal operations of LZC system at Wolsong 2 can be divided into two periods. One is the sudden drop with continuous operation mode of LZC compressor and the other one is cycling with the on-off operation mode of the LZC compressor. It is identified through the communication with other CANDU reactors that this phenomenon is not unique to Wolsong. Whenever the upper side zone (1,8,6,13) level exceeded 80%, these abnormal operations occurred and mismatch between indicated and actual zone level was found. Counter-plan is prepared to ease these abnormal operations by physicist' own efforts at Wolsong 2.

## 2. LZC System Exceeding phenomenon

### *2.1 Introduction to Liquid Zone Control System*

As one of the reactivity control system, the Liquid Zone Control System controls the reactivity by adjusting the light water($H_2O$) level inside of the total 14 cylinder type compartments. In each axial end of the reactor, there are 3 Tube Unit Assemblies, which are divided by 7 compartments. The central Tube Unit Assembly is divided by 3 compartments, while the other 2 side Tube Unit Assemblies are divided by 2 compartments.

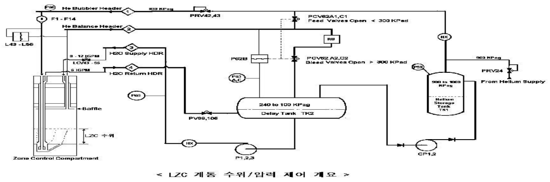

Figure 1. Liquid Zone Control System

The light water volume within the compartments would be controlled by bulk control and spatial control, and helium gas is used as cover gas for the upper side of the compartments. The reactivity control ability of the compartments is approximately 6mk. The outlet flow for each compartment is fixed at 0.45 l/s by maintaining the differential pressure between the He Balance Header and the Delay tank, and the inlet light water flow is changed from 0.1 l/s to 0.9 l/s. Light water supplying pumps are operating for circulation of light water in LZC. LZC compressor transports the helium gas from Delay Tank, which is used to maintain system differential pressure as constant, to helium supply tank. The compressor is operated on "AUTO" mode that it will run at 2.4 bar and stop at 1.0 bar.

To adjust the light water level of each compartment, the Level Control Valve opening is decided, considering the Flux Tilt and Level Tilt of individual zone which are calculated by the Reactor Regulating System (RRS). When each zone level reaches above 80% or below 10%, it is gradually inhibited for Flux Tilt to produce further level deviation, in order to preserve the margin for bulk power control and to prevent light water flooding and to protect equipment.

### *2.2 Water level exceeding phenomenon of the Liquid Zone Control System at Wolsong 2*

Before the Plant Outage on 1999, the compressor of the Wolsong 2 was operated continuous mode due to the problems with the light water supplying pumps on LZC system. Under these circumstances, it was repeatedly confirmed that if the level of zone #13, which is located in upper side region, rose above 80% after refueling, then it could not decrease slowly according to the flux reduction, but it remained constant or slightly lower than 80% for 2-4 days, and then after showing a sudden drop of more than 40%, it returned to its normal level. (Fig. 2) [1].

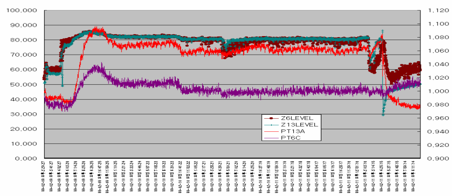

Figure 2. Water level change at the zone 13 after the refueling (D-18, K-03: '99. February)

After the Plant Outage on 1999, the operation mode of the compressor at Wolsong 2 changes into the "AUTO" mode, i.e., on-off operation mode, which is original design operation mode. At this mode, when the level of the upper side zone (1, 8, 6, 13) exceeded 80%, it showed up and down cycling phenomenon, whose period was just same as the compressor's on-off period.

### *2.3 Water level exceeding phenomenon at the Liquid Zone Control Systems of the other CANDU reactors*

During the similar time when the cycling phenomenon was reported at Wolsong 2, the identical problem was also reported at the Zone #1 (only Zone #1) of Wolsong 1. Furthermore, Wolsong 3 and 4 were sequentially experienced the identical phenomenon, which allowed us to assume the existence of some common points [1].

Among the oversea CANDU reactors, the cycling phenomenon did not occur at Pt.Lep and G-2, whereas the upper side zone of the Darlington 3 & 4 reactors showed the identical sudden drop which was same as the early type of Wolsong 2 [2].

*2.4 Estimation of indicated water level error by using the ROP(Regional overpower protection) detector*

Through the investigation of correlation among the reactors of Wolsong 1 (only zone #1), Wolsong2, 3, and 4, Darlington 3 & 4, Pt.Lep, and G-2 Nuclear Power Plant, it was identified that the design of Unit Assembly in the Liquid Zone Control System had been modified. The existing tube type of unit assembly was found to cause the abrasion by vibration in Pt.Lep, G-2, Wolsong 1, and Bruce Power Plant. The abrasion was found to cause the error within the water level measuring device, and consequently make it difficult to get the accurate water level.

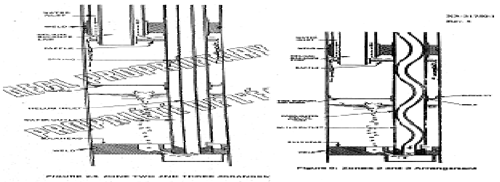

Figure 3. The Liquid Zone Control Unit Assembly of the Wolsong 1, 2, 3, and 4 reactors

Because of the above reason, the corrugated type, which does not have Centering Spring, replaced the spring type as the bubbler tube unit assembly, by the result of the COG (CANDU Owner's Group) Joint project. All of the plants, having upper side zone problem, used the corrugated type bubbler tube unit assembly (Fig. 3).

To prove that indicated water level is not correct during Cycling, Wolsong 2, for the first time, attempted to estimate the actual level using the Regional Overpower Protection (ROP-Pt) detector signal which is not related with zone level variation, RRS-Pt. detector signal which is used for zone level control, and reactivity property [3]. Figure 4 illustrates the estimation result of actual water level at the zone 1 by using the ROP-Pt detector that is not directly related to the water level variation and by using the zone level reactivity property.

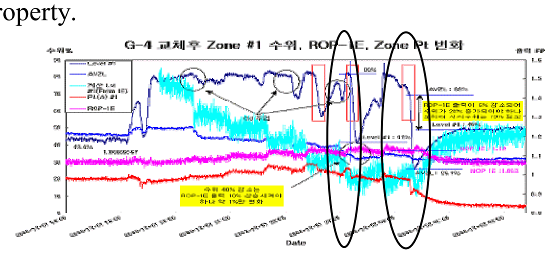

Figure 4. Comparison of indicated water level and actually assumed water level (based on ROP-1E signal) at the zone 1

Although the indicated water level on RRS showed 80%, the actual level gradually decreased to 15% as the water continuously drained from the core. So, zone power was increased slowly. Estimation for the period of recovery was done too.

*2.5 Estimation of indicated water level error through the Mock-up construction*

The additional estimation for indicated water level error has been conducted by constructing a Mock-up of upper side Zone#8(Spring Type) in Kyung-Hee University. It showed that though the indicated level maintained about 80%, it could not suppress the power increase as the actual water was drained out of the reactor. It also showed that the cycling was developed by the blocking of water flow by the internal structure supporting panel in the zone controller. However, as it was tested for existing Spring Type tube which was not the same corrugated type in Wolsong 2, 3 and 4, and because its result is different from the experience that the cycling does not occur in upper side zone (8, 6, 13) in Wolsong 1, the test result is accepted limitedly.

## 3. Conclusion

So far, the fundamental reason for the exceeding phenomenon at the upper side zones of Wolsong 2, 3, and 4 has not been clearly elucidated, it is clear that the phenomenon occurs at the power plants where using the corrugated type tube unit assembly. During the period when the exceeding phenomenon was present, the measurement of actual water level by using two different types of detectors (RRS-Pt & ROP-Pt) resulted to show the significant difference to the indicated water level in RRS. Even if the fundamental reason for the abnormal operation was found, the problem adjustment through equipment remodeling is substantially impossible. So, the temporary modification was applied a software methodology to ease these abnormal operations at Wolsong.

## REFERENCES

[1] S. M. Kim COG/AECL CANDU Liquid Zone Control Work Shop "LZC System Instability of Wolsong2" Oct., 2001

[2] Gene Hutchinson COG/AECL CANDU Liquid Zone Control Work Shop "Darlington NGS Unit 4 Flux Tilt Events" October, 2001

[3] S.M. Kim, J.W. Park "Error of Indicated Level of the Upper Side Zone (1,8,6,13) of LZC at Transition" Feb., 2004