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Feasibility Study of Power Uprate Using Ultrasonic Flow Meters in NPPs

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1. Introduction

Feedwater flowrate is an important input parameter in establishing the plant's operating power level. In Korean nuclear power plants, venturi flow meters have been used for measuring the feedwater flow of the secondary side. However, as time goes on, the fouling in venture meters could cause measurement uncertainties to grow and that could lead to operation at less than about 2% of the licensed thermal power limit [1].

In order to resolve the problem, nuclear power plants in other countries use Ultrasonic Flow Meters (UFMs) which have relatively lower measurement uncertainty (about 0.5%) instead of venturi flow meters and have reduced the errors from the fouling in venturi-type flow meters. USA amended 10 CFR 50 Appendix K so that US nuclear power plants can use real value of Core Operating Limit Supervisory System (COLSS) uncertainty, which is currently fixed as 2%, by adopting the UFM. Korea also has been amended the law in order to get benefits from the technology [2].

In this study, we are going to present the fundamental principles of UFMs and the advantages and disadvantages of its installation. Also, we inquire into the conventional uses of UFMs in the overseas sites and then check what is needed to consider for its domestic application.

2. Status and Perspectives

2.1 Power Uprate

Power uprates are divided into three part, Measurement Uncertainty Recapture (MUR), Stretch power uprates (SPUs), and Extended power uprates (EPUs). It is categorized based on the magnitude of the power increase and the methods used to achieve the increase. MUR power uprates result in power-level increases of less than 2 percent and are achieved by implementing enhanced techniques for calculating reactor power. SPUs typically result in power-level increases of up to 7 percent and generally do not involve major plant modifications. EPUs result in greater power-level increases than SPUs and usually require significant modifications to major plant equipment.

This paper discusses one way of MUR power uprates by replacing the existing venturi flow meters to UFM in order to reduce the errors in measurements of main feedwater.

2.2Types of UFM

There are two types of UFM, one is CROSSFLOW of Westinghouse Electric Corporation (WEC)[1] and the other is LEFM Check Plus system of Caldon[2] which is being selected for installation in nuclear power plants. The US Nuclear Regulatory Commission (NRC) staff completed its reevaluation of the generic approvals previously granted for these UFMs. On July 5, 2006, the staff's reevaluation concluded that the performance of the Caldon LEFM Check Plus is consistent with previous NRC reviews and therefore is acceptable. However, The NRC suspended its approval of the WEC Crossflow UFM topical report for new and future use in power uprate applications due to reasons including insufficient instructions about using and installation and the uncertainty of its use in the real plant operation conditions. The paper which was previously approved on March 20, 2000 loses effect, and the new and future use of WEC Crossflow is prohibited. The NRC rejected an application from the plant Fort Calhoun, and plant Calvert Cliffs 1, 2 voluntarily withdrew their requesting approval; both plants had requested the approval of using WEC Crossflow [2].

2.3 Installation Point of UFM Transmitter-Receiver

We should set up the point of transmitter-receiver to use UFM. The set points may differ from manufacturer to manufacturer. Generally, the straight section of the pipe should be fifteen times longer than its diameter for liquid. In the case of steam or gas, the straight section should be thirty times longer than the diameter. Furthermore, for liquid, the direct section of the front side of the transmitter-receiver has to ten times of the pipe's diameter and the straight line is five times of the diameter at the back side of the transmitter-receiver. Also in case of steam or gas, front side is needed to be twenty times and back side is needed to be ten times longer than the pipe diameter.

According to the main feed water calibration experiment by using UFM which was performed at Korea Power Engineering Company (KOPEC) in 2003, the straight line of the Wolsong plant is forty-one times longer than the diameter. Therefore, it is suitable for the installation of UFM [5]. Figure 1 is example of installation a transmitter-receiver in liquid case.

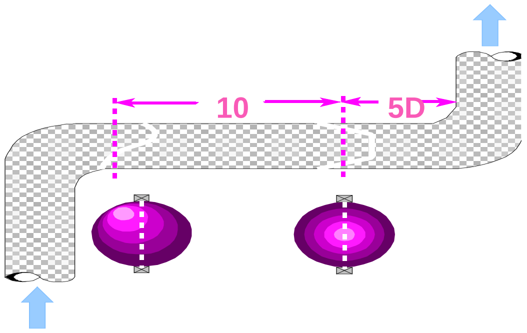

Fig. 1 Example of a transmitter-receiver installation

2.4 Installation Status

Table 1 shows the names of the plants in which Caldon LEFM Check Plus has been installed and their date of approval [3].

Table. 1 Installation Status of Caldon LEFM Check Plus

Plant	Approval Date
Davis-Besse	08/06/30
Cooper	08/06/30
Crystal River 3	07/12/26
Seabrook	06/05/22
River Bend	03/01/31
D.C. Cook 1	02/12/20
Indian Point 3	02/11/26
Peach Bottom 2	02/11/22
Peach Bottom 3	02/11/22
H. B. Robinson	02/11/05
Grand Gulf	02/10/10
Sequoyah 1	02/04/30
Sequoyah 2	02/04/30
Waterford 3	02/03/29
Comanche Peak 1	01/10/12
Comanche Peak 2	01/10/12
Beaver Valley 1	01/09/24
Beaver Valley 2	01/09/24
Susquehanna 1	01/07/06
Susquehanna 2	01/07/06
Watts Bar	01/01/19
Comanche Peak 2	99/09/30

2.5 Power Uprate Status

Since Comanche Peak 2 was approved for the power uprate by NRC on September 30, 1999, there are 40 other nuclear power plants too, which has been approved for the power uprate until now, and those power uprates has been resulted in a combined increase of about 26.51MWt (79.53MWe).

Two nuclear power plant, Calvert Cliffs 1,2, is currently under NRC staff review since they have requested the approval on August 29, 2008 and it could add an additional 1.036MWt (3.108MWe) to the electric generating capacity if approved.

Also, NRC is expecting that there would be 20 more nuclear power plants successful in their power uprates until 2013 and anticipates that it reaches about 42.0MWt (126.0MWe) [4].

2.6 The Advantages of UFM Installation

If the main feed water flow meter is replaced by UFM, the power plant's output rate can be raised up to 1.7%. According to the survey of License Event Reports since 1983, we can avoid the overpower transient at least 33 times if we install UFMs. If all nuclear power plants in United State install UFMs and get 1.7% of power uprate at each unit, it would result into 850.0MWt (2550.0MWe) and it would have the same effect as a new nuclear power plant.

3. Conclusions

The power uprate by using UFMs seems no effects on the safety of nuclear power plant. It is basically to reduce COLSS uncertainties which have been calculated by Modified Statistical Combination of Uncertainties (MSCU). Therefore, once it is verified that each plant satisfies its installation requirements, this method could bring many business benefits to the nuclear power industry.

ACKNOWLEDGEMENT

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[2] Nuclear Regulatory Commission, NRC regulatory issue summary 2007-24, NRC staff position on use of the Westinghouse crossflow ultrasonic flow meter for power uprate or power recovery, 2007
[3] Nuclear Regulatory Commission, Status of power uprate applications, www.nrc.gov.
[4] Nuclear Regulatory Commission, Power uprate program status report, 2008
[5] Korea Power Engineering Company, INC, Development of the Ultrasonic Flow Measurement Technology for the Feedwater Flow in Nuclear Power Plant, 2004

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[1] WEC is now a unit of Toshiba Corp. of Japan and Britain's AMEC.
[2] Caldon is now a part of the Measurement Systems division of Cameron International Corporation ("Cameron")