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Development of Wireless System for Containment Integrated Leakage Rate Test

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1. Introduction

The containment system leakage rate should be estimated periodically with reliable test equipment. In light-water reactor nuclear power plants, ANSI/ANS-56.8 is a basis for determining leakage rates[1]. Two types of data acquisition system, centralized type and networked type, has been used. In centralized type, all sensors are connected directly from sensors in the containment to the measuring equipment outside the building. The other hand, the networked type has several branch chains which connect one group of the network-sensors together. To test leakage rate, more than 20 temperature sensors and 6 humidity sensors, which are different for each plant, should be installed on a specific level in the containment[2]. A wireless technology gives the benefits such as reducing installation efforts, making pretest easy, so it is widely used more and more in the plant monitoring[3][4]. As the containment system has many kinds of complex barriers to the radio frequency, the radio power and frequency band for better transmission rate as well as the interference by the radio frequency should be considered. The overview of the wireless sensor system for the containment leakage rate test is described here and the test results on Yonggwang unit 4 PWR plant is presented .

2. System Overview

2.1 System Diagram

The wireless CILRT system consists of the wireless sensors for temperature and humidity, relay stations for unwire-wire transmission conversion, and control computers for the data acquisition control and real-time leakage analysis. Figure 1 shows the schematic diagram of the wireless CILRT system. For reliable transmission between the control computers and the sensors, the redundant networks are used. Besides, the test software is functionally, independently divided into the data acquisition part and the analysis part. The data acquisition software, DAQServer, links the sensors, pressure monitors on the network and gives commands to them to get data with specified period. The analysis software, ILRT Expert, gets measured data from DAQServer periodically, and calculates the total air mass and leakage rate using mass point basis. Analysis software has several windows for the specific test steps as shown in Figure 2.

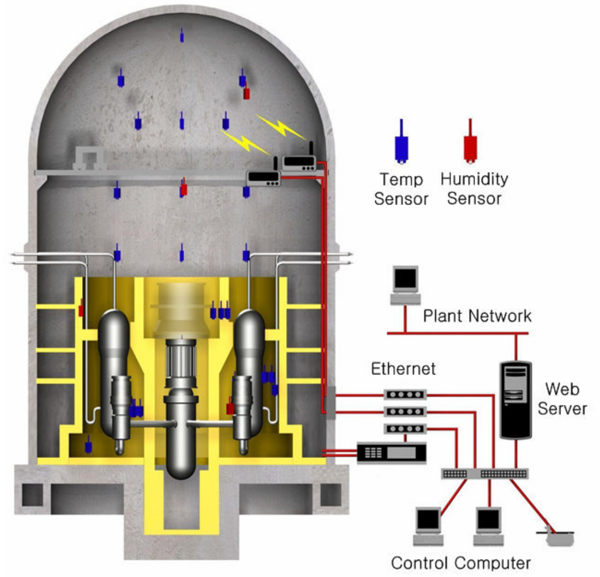

Figure 1. Diagram of the wireless CILRT system

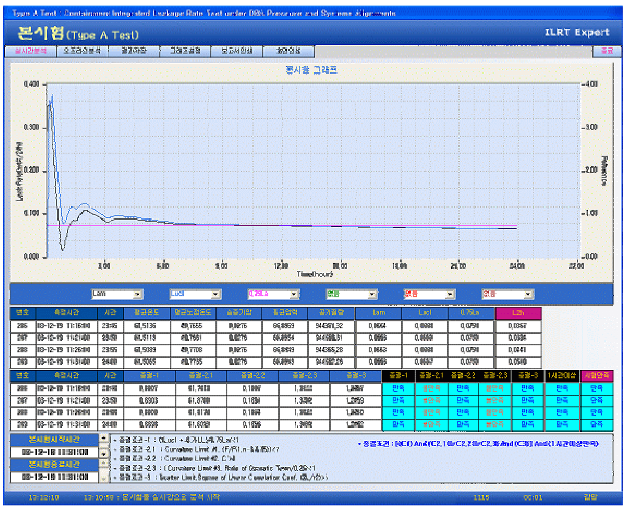

Figure 2. Analysis Software, ILRT Expert, for CILRT

2.2 Wireless Transmitter

Three types of sensors for temperature, humidity, and pressure, are used for CILRT. The wireless transmitters for temperature and humidity were developed as the same hardware and software platform. The transmitter is presented in Figure 3. Platinum RTD with 4-Wire technique provides accurate and reliable temperature measurement. Also, thin-capacitive humidity sensor gives the linear, low power consumption measurement of humidity. Polymer battery guarantees more than 300 hours operation time and is enough for whole test duration. Besides, all transmitters stores the measured data automatically with same period on their inner memory more than 5 hours. After transmission failure is returned to recovery, the control computer can get all data in the transmitters at a time.

Figure 3. Wireless Transmitter

2.3 Plant Test

To evaluate the performance of the wireless transmitter, two types of transmission test was conducted. One is done on the plant with similar mechanical and electrical structures, the other in the containment of Yonggwang unit 4 PWR plant. The test results on similar plant for 28 hours showed 99.98% success rate. In Yonggwang plant, a relay station was installed on the top of the pressurizer room instead of on the polar crane, and three transmitters were installed on the same location which considered as the harsh transmission environment. The transmitters measured temperature and humidity periodically by the command of the control computer and transmitted to the computer. The test results are shown in Table 1.

Table 1. Transmission test results in Yonggwang unit 4 with one-trial.

Test Location	Sensor#1	Sensor#2	Sensor#3
R20 (127′)	39/0/39	39/0/39	39/0/39
R21 (127′)	28/0/28	28/0/28	28/0/28
R22 (100′)	19/4/15 26/0/26	19/8/11 26/0/26	19/0/19 26/6/26
R23 (100′)	27/0/27	27/0/27	27/0/27
R26 (133′)	35/0/35	35/3/32	35/0/35
R27 (133′)	26/0/26	26/0/26	26/0/26
R28 (117′)	45/0/45	45/0/45	45/0/45
Total/Fail/Success Success(%) (One-Trial)	245/4/241 **98.4**	245/3/242 **98.8**	245/6/239 **97.6**

The results showed the 100% success for two transmission trials and more than 97% success for one trial. In case of two transmission trials, about two more seconds are needed to get a measured data from each sensor. R22 is the lowest level of the containment and the failure rate is relatively high. This troubles in communication can be solved by using the remote sensor cable which connects the remote sensor to the transmitter. The sensor cable is desirable less than 10m but was not used this test.

3. Conclusion

The containment leakage rate test system using the wireless technology was implemented and tested at Yonggwang unit 4. The transmission test results showed the usefulness for reducing the installation efforts and pretest time of sensors, as well as for more reliable leakage rate test results. For more success rate in data transmission, the remote sensor cable is recommended in the low level of containment.

REFERENCES

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