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Smart Integrated Containment Leakage Rate Test System using Wireless Communication

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1. Introduction

Integrated Leakage Rate Test (ILRT) is the important test the confidentiality and integrity of the containment building, which is the last barrier when Design basis accidents (DBA) of Nuclear Power plant occur.

Since the result of this test is the basis to guarantee the safety of nuclear power plants, the test process, test procedure, and the test equipment are required to have high reliability.

The test devices previously used have been products of VOLUMERTRICS and GRAFTEL of USA. These devices have been inconvenient to calibrate and use. Thus improved devices needed to be developed to remove the inconveniences, to verify the safety of Korean nuclear power plants with Korea's own technology, and to secure core technology. A new leak test system was developed by domestic technology for that purpose and needed to be verified.

In this paper, technical details of the newly developed easy-to-use and highly reliable measuring test device, which is in operation at the nuclear power plant sites, will be introduced. State-of-art technology was applied to the device to address the shortcomings of previous US-made devices and the difficulties to use on site.

2. Smart Integrated Containment Leakage Rate Test System using Wireless Communication

2.1 Status of measurement System

The existing test devices were developed by VOLUMETRICS and GRAFTEL of USA . They are different configuration that the sensor and the data acquisition part are separated in VOLUMETRICS device but integrated in GRAFTEL device. Both devices are inconvenient for they are wired to transmit data. Especially in VOLUMETRICS device great effort is required to ensure the reliability of line instrumentation loop between the sensor and the data acquisition system.

Since Korean ILRT system had been developed to substitute VOLUMETRICS and GRAFTEL products have been used for testing containment buildings.

2.2 Smart Integrated Containment Leakage Rate Test System development

2.2.1 Test device configuration

Smart Integrated Containment Leakage Rate Test System consists of wireless temperature and humidity transmitter to measure the dry-bulb temperature and relative humidity inside the containment building, standard precision pressure instruments, DAQ computer to acquire and store data, and a computer to analyze the data.

Wireless repeaters that are installed within the containment building receive data values (Digital Value) via wireless communication from wireless temperature transmitter and wireless humidity transmitter. Wireless repeaters are connected to ILRT equipment installed in ILRT room with RS485 cable which penetrates through the containment building. Two channel precision pressure instrument is connected with copper tube, T-type fitting, and valves through pressure pipe.

2.2.2 Wireless smart sensor

Wireless smart sensor is an integration of a sensor, a data acquisition unit, and a wireless transmitter. One wireless smart sensor can measure one value.

The sensor uses 424.7 MHz frequency and consumes 10 mW. The wireless communication range is 1 km in open area and the internal battery can supply power up to 30 days of continuous use.

Temperature is measured with a 4-wire RTD sensor, and relative humidity is measured with capacitive RH sensor. Pressure is measured with a standard precision pressure instrument, which is easy to maintain and apply.

The table below compares the ANSI/ANS-56.8' 94 instrumentation requirements and the performance of the wireless smart sensor.

Table 1 Comparison of ANSI/ANS-56.8'94 instrumentation requirements and the wireless smart sensors

ANSI/ANS-56.8 '94 instrumentation requirements	wireless smart sensors
1. Dry-bulb temperature. Accuracy : ±0.55℃ Resolution : ±0.017℃ Repeatability : ±0.11℃ 2. Relative humidity Accuracy : ±3.5 %RH Resolution : ±1 %RH Repeatability : ±0.5 %RH 3. Absolute pressure Accuracy : ±0.02 psi Resolution : 0.001 psi Repeatability : ±0.005 psi	1. Dry-bulb temperature. Accuracy: ±0.4℃ Resolution : ±0.010℃ Repeatability : ±0.05℃ 2.Relative humidity Accuracy : ±2 %RH Resolution : ±0.01 %RH Repeatability : ±0.3 %RH 3. Absolute pressure Accuracy : ±0.008 psi Resolution : 0.0001 psi Repeatability : ±0.0005 psi

Figure 1. Wireless smart temperature and humidity sensors and repeaters

2.3. Verification testing of the device according to the environment

The wireless smart sensors were tested whether they performed required functions under the given environment while they are transported, stored, and used. Applied standard was IEC Pub.62000 Basic environmental testing procedures.

2.3.1 environment test

The wireless smart temperature and humidity transmitters were installed in the environment conditioned constant temperature and constant humidity chamber. And the temperature sensor and the humidity sensor were installed in calibrating constant temperature constant humidity chamber. The environment condition is shown in Figure 2 and temperature and humidity is shown in Figure 3. It is evaluated if it satisfies the ANSI/ANS-56.8 '94 instrumentation requirements

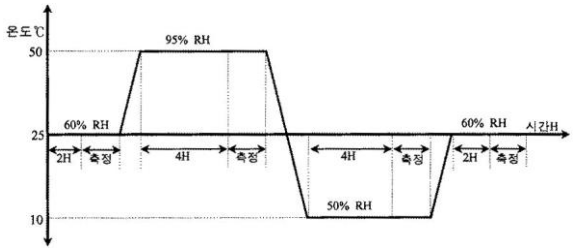

Figure 2. Environmental conditions in graph

2.3.2 Vibration Test

To test the durability of the samples under specified severity of vibration, one temperature transmitter, one humidity module, and one repeater were tested in the condition shown in Table 2 in power-on state. They were measured as in Figure 3 and evaluated if they satisfy the ANSI/ANS-56.8 '94 instrumentation requirements

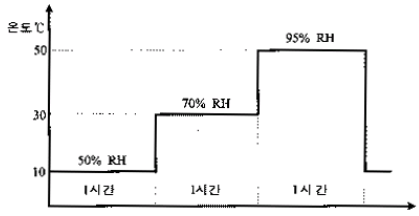

Figure 3. Calibration-grade thermostat, hydrostat temperature, humidity graph

Table 2 Vibration test conditions

Parameters	Test conditions
Vibration direction	X, Y, Z axis
Test frequency	5Hz ~ 55Hz
rate	1 Occtave/min
Test time	30 min/axis
method	logarithm

2.3.3 Pressure test

Since the ILRT is performed under pressurized condition, the same environment pressure condition shown in Figure 4 was applied to check if the pressure instrument operated normally.

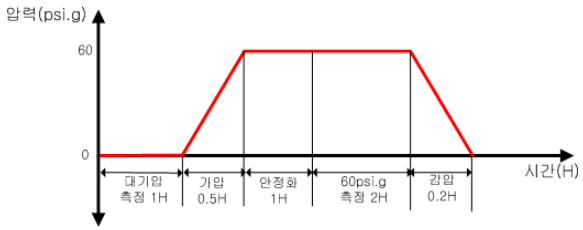

Figure 4. Pressure test graph

3. Conclusion

This paper is intended to introduce the Smart Integrated Containment Leakage Rate Test System which is developed to provide easy operation, short operation time in preparation and high accuracy and reliability of equipment in tests in ILRT of domestic nuclear power plant containment buildings.

Until now ILRTs have been carried out successfully on 9 domestic nuclear power plant units with this system and we are contributing to the improvement of domestic technology in the field of nuclear power plant instrumentation.

REFERENCES

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