Gas Void Monitoring and Control System (GVMCS) development for Gas Intrusion and Accumulation in Nuclear Power Plants

Yong Jae Song [a*], Jong Chan Lee [a], Woo Young Jung [a], Hee Kwon Ku [a], Hee Dong Kim [a], Dae Seong Jo [b]
[a]Future and Challenge, Co,. Ltd.
[b]*Kyungpook National University*
[*]*Corresponding author: songyj@fnctech.com*

1. Introduction

Gas intrusion and accumulation issues in plant safety systems have been an ongoing concern for many years and Instances of gas accumulation in Safety Related System (or Safety Injection Lines) have occurred since the beginning of commercial nuclear power plants (NPPs) operation [1, 2]. For other types of Plants such as Chemical Plants, Coal Plants, etc. Gas accumulation in the pipes can cause many safety problems such as 'Water Hammering', 'Flow Induced Vibration, and 'Cavitation'. The NRC has issued a number of information notices and Generic Letters (GLs) on the subject. In 2008, the NRC issued GL 2008-01[1] to comprehensively address gas accumulation issues and to request each licensee evaluate its emergency core cooling, decay heat removal, and containment spray systems for licensing basis, design, testing, and corrective actions regarding pump response to suction voids. In addition, the NRC requested that licensees demonstrate that the subject safety related systems comply with the applicable regulatory requirements to ensure that gas void accumulation and transport as the result of de-aeration or air ingestion, or both, is maintained less than the amount that challenges operability of these systems and that appropriate action is taken when conditions adverse to quality are identified. Licensees should evaluate and address de-aeration, flashing, and other air entrainment mechanisms, as discussed in GL 2008-01.

These include sources of gas, gas accumulation locations, determination of gas quantities, water hammer, cavitation, fluid induced vibration, and acceptable gas quantity with pump operation and control of gas [3].

GVMCS aims at reducing the need for repeated containment entries for monitoring gas voids in high radiation, hard-to-reach locations by automatic venting.

The objective is to develop a Gas Void Monitoring System and controls the void for increase of Safety for Nuclear Plants and other Plants. Another objective is to develop a commercial system for monitoring Gas Void in the plants permanently.

This study introduces the process of developing the nuclear-graded system with experimental data and program for controlling the system.

2. Test Methods, Facility, and Commercial Product

The purpose of the tests is to measure the void fraction in the pipe without changing of configurations, material, and other conditions of plant conditions and to develop a controlling system of gas void in the pipes. A program for controlling the system has been also developed and has been tested.

As mentioned in Section 1, developing system would be applied to actual plants and should not modify and change any of piping systems in the plants. Water level measuring methods should not perforate, cut, or add any new vent valves.

2.1 Test Methods

In order to evaluate the amount of gas void in the pipes, measuring and test methods must be completed. The results of tests would determine how an initially stationary gas accumulation is affected by temperature and pressure.

An ultrasound is used to measure the water level inside pipes. Figure 1 and 2 show the ultrasound system and water level displayer for measuring water levels.

For this test facility and system that would identify potential gas intrusion mechanisms, evaluate the amount of gases in the pipes. This test must consider void fraction in the pipes, transport to pumps, and controlling the voids must be performed to prove the Gas Void Monitoring and Controlling System.

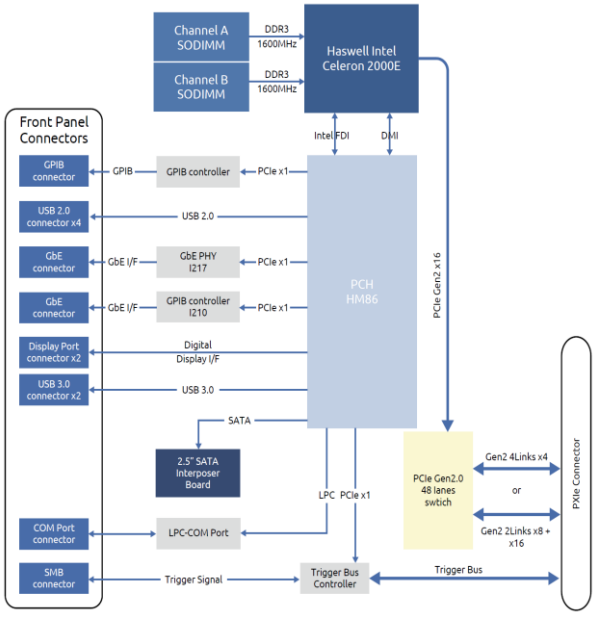

Figure 1. Ultrasound and System

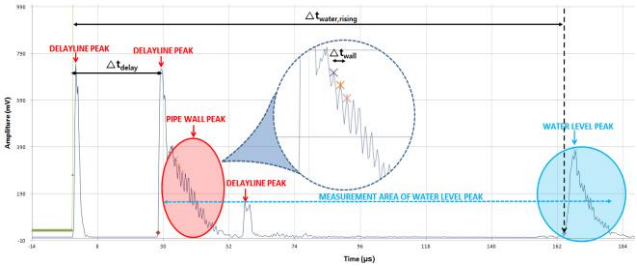

Figure 2. Output from Ultrasound System

2.2 Test Facility

As described in section 2.1, to test and prove availability of GVMCS, a test facility has been built. Figure 3 and 4 show the test sections of 2", 4", 6", and 14" for simulating the actual plants. Each pipe is made with the two different materials that are stainless steel 304 and Carbon Steel. The test facility consists of a pump, air actuated valves, flow control valves, air injection, and horizontal pipes. Especially, there is a moving test section (only 14" pipe) to simulate the inclined pipe in the plants. It makes the pipe enable to incline and hold the position. For visualization of water level inside the pipes, a half of a test section is made by acrylic.

Figure 3. Test Facilities

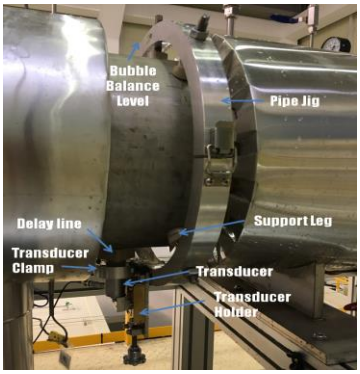

Figure 4. Clamp for Ultrasound System (14 in)

2.3 Commercial Product

The output of current tests and study is a commercial product to measure, automatically vent, and continuous monitor piping systems in plants. This system will be the first monitoring and controlling system, which enable to operate in safety way by controlling the void fraction in the safety injection piping systems.

Figure 5 shows the commercial product that will be installed in the plants.

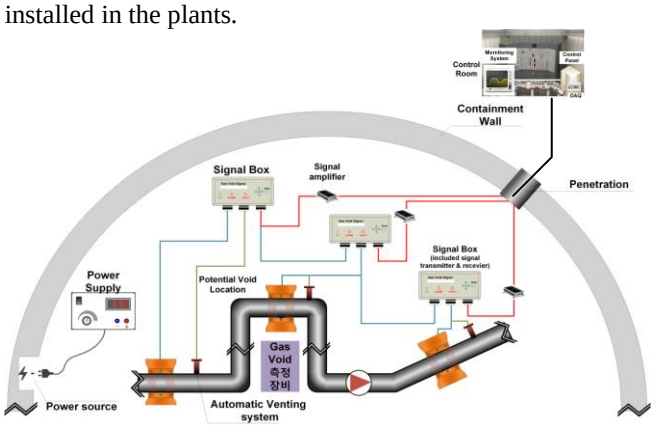

Figure 5. GVMCS for Plants

2.4 Future Work

1. Testing the Ultrasound system with high temperature environment.
2. Optimizing the delayline design.
3. Upgrading the software program for fine controlling
4. Making a commercialized system for tests

The GVMCS should be qualified by regulatory and other qualified institute before installing the system in the plants, high temperature, radiation, and seismic tests must be done and qualified.

3. Conclusions

A test version GVMCS has been developed and ptest facility has been built for testing the ultrasound and related systems. 2 in, 4 in, 6 in, and 14 in test sections have been built for simulating the representative piping in the plants.

A commercial product has been developed with various test conditions and now it's in upgrading stage for actual tests at the plants and a commercialized system will be developed in near future.

REFERENCES

[1] NRC Generic Letter 2008-01, Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems, Jan. 2008

[2] NRC Regulatory Issue Summary, NRC Endorsement of NEI 09-10, Rev. 1a-A, Guidelines for Effective Prevention and Management of System Gas Accumulation, Sept. 2013

[3] NRC Information Notice, Component Cooling Water System Gas Accumulation and Other Performance Issues, July 2011