Study on Early Leak Detection of PCS Coolant Using Integrated System by means of Multi-Sensors Technique

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1. Introduction

The leak detection of primary coolant in a nuclear power plant containment which resorts to technology of the relevant sensors and integrating manner of those has been studied for long years. The jacket or gasket or like connection part which encloses the primary coolant likely leaks due to high pressure and is getting more vulnerable feature as times elapse. Furthermore, this leak is hardly detected until it severely progresses and may not only impair the reactor operation but also aggravate the plant safety. Due to the fact, it becomes more important to devise the scheme that can effectively and initially diagnose such kind of system fault. In this paper, early detection of leaks under high pressure is proposed. In particular, the way to integrate the multi-sensors is moderately introduced and how to develop further will be discussed.

2. Early leak detection system with multi-sensors

In order to exactly detect whether certain leak occurs or not in PCS (primary cooling system) coolant, many kinds of schemes in a possible manner have been brought up so far. However, the much earlier detection as well as identifying where it happens becomes more significant issue to enhance the reactor safety. The conventional method to tell the anomaly like small leak takes an example of the sump level indication as a representative. The pros and cons for this technique is already well-known but the point is that it has too slow response and low credibility to judge overall status of plausible phenomenon. This is the reason that the early detection of small leak in site should be actively addressed as shown in Fig.1

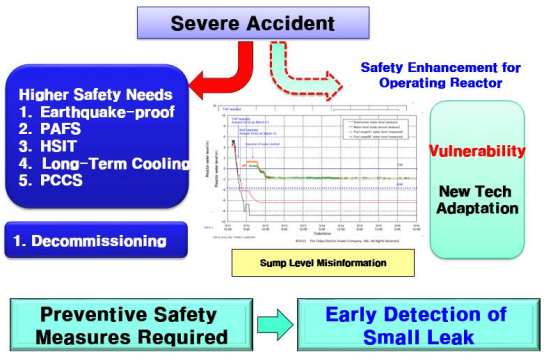

Fig. 1. Needs of early detection of coolant leak in site

Given that materials used for the primary cooling system are sufficiently robust, small cracks resulting in much larger leakage which can be detected by the existing leakage detection systems will remain stable and not lead to component rupture. Apart from this, the early leak detection concept is used as a part of the general safety assessment.

The main problem in a traditional approach for leak detection takes longer time to accumulate the data such as sump level, humidity around the reactor and consequently leads to latent delay of identifying occurrence of leaks in site. Thus, the trend for leak detection of PCS coolant should be turned to the scheme which a few principles as followings; based off system-wise, focused on the specific area, more sensors allocation for high sensitivity in Fig. 2 are to be adopted. To effectively implement these real-time, substantially diverse detection system, we have to establish overall leak detection equipped with the multi-sensors.

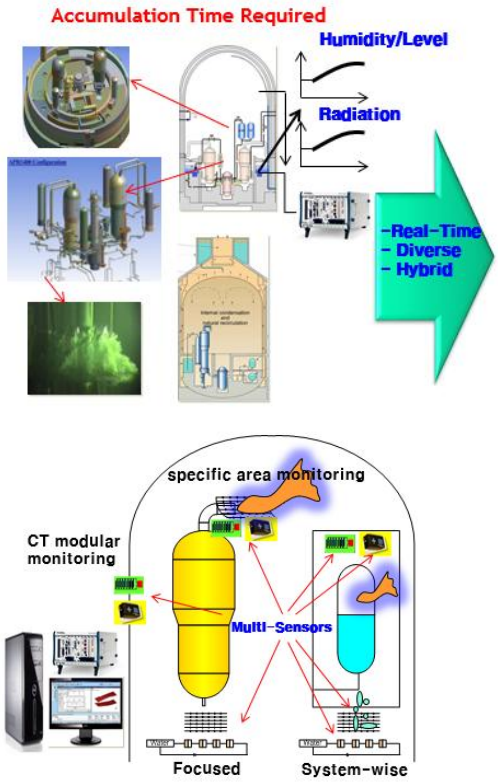

Fig. 2. More advanced integration of early leak detection with multi-sensors

3. Overall process of integrated early leak detection

Basically, the early leakage detection is essential under being pressurized on account of small leaks possibility developing to larger leaks and thus could cause catastrophe such as ruptures which could result in loss of coolant accident (LOCA). Despite the fact that leaks from cracks rarely occur, such conditions must be monitored for safety of plants. In particular, due to fluid leak from the flange joints, valves etc. should be continuously monitored and prevented as possible.

Integrated early detection method can fall into following subgroups; measurement of relative air humidity in SG box, sump water level in SG, gaseous radioactivity in SG box, and condensate flow after the air venting system. First, relative humidity in the SG box atmosphere depends significantly on the ambient humidity and temperature in the measuring location. Due to this fact, the humidity sensors often differ their measurements in a large range (about 5H-10%), and thus the humidity obtained as a result of a leak can be hidden. The humidity sensors in the containment can detect a leakage where their disadvantage is the uncertainty of unknown liquid/vapor ratio on account of their location and leakage information has only a general location of the leak source. By and large the humidity level monitoring can be used as an indirect method for primary circuit leakage detection, which limits its application as a qualified system.

Next, sump level is to monitor the changes of the water level in the SG box collecting tanks (sumps). To determine the boundary value of the leak, two boundary cases are examined where at the initial humidity 30% and 60% and temperature within the range 40°H-60°C. This calculation is to determine the flow rate through the crack while condensate happens in SG box. The leak flow rate for any combination of initial parameters of SG box atmosphere (temperature and humidity), are obtained by changing the crack flow area until 100% humidity in SG box is reached. The third analyzed method is leakage detection by monitoring the activity of radioactive aerosols and radioactive gases in the confinement atmosphere. This measurement carried out in the non-serviceable compartments plays the role of technological control for leak detection from PCS equipment. The most representative of the radiation situation is on the basis of the gas aerosol activity in the controlled area is the measurement of beta-gases, aerosols and iodine vapors. For the exact information considered every kind of leak measurements, the suitable sensors for humidity, flow rate, sump level, radiation as well as its location are determined. Furthermore, all data from local sensors are effectively transmitted to the main server that has leak assessment algorithm. The integrated scheme for early leak detection is seen in Fig 3.

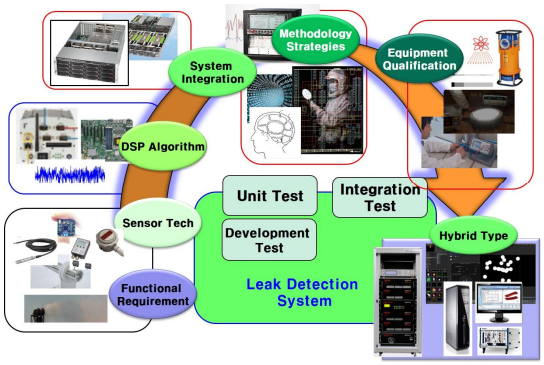

Fig. 3. Integrated scheme for early leak detection

4. Conclusions

Thus far, the issue of early leak detection of primary coolant in a nuclear power plant has been dealt with, and a simple approach for the integrated manner using multi-sensors. A vulnerable connection/joint part which encloses PCS likely leaks due to high pressure and this matter still lingers on our mission down the road. The suggested method basically enables to detect any small leak with real time through hybrid differently located sensors. However, the some measurement detail such as beta-radiation detecting still remains challenging and hence we need to increase the feasibility of this scheme by perseverant testing.

ACKNOWLEDGEMENT

This research (20181510102340) was supported by KETEP and MOTIE for the project “Development for unidentified RCS small leak detection system” with MMIS research team in Korea Atomic Energy Research Institute.

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