Containment vessel pressure behaviors at Unit-2

1. Introduction

The measured values and analysis results of containment vessel (PCV) pressure changes at Unit-2 were inconsistent in the earlier report*1 submitted to the Nuclear Industry and Safety Agency on May 23rd, 2011. The following items are the estimated causes of these discrepancies and the phenomena assumed in the present MAAP analysis reported in March 2012. Figure 1 and Figure 2 present the PCV pressure changes obtained in the May 2011 analysis. The red frame in each figure shows where the measured values and analysis results were not consistent.

2. MAAP analysis in May 2011

When the heat removal from the PCV is insufficient, the pressures of the dry well (D/W) and suppression chamber (S/C) increase because the steam generated in the reactor is discharged to the S/C via the reactor core isolation cooling system (RCIC) or safety relief valves (SRV). Pressures measured of the D/W and S/C of Unit-2 increase more slowly than the prediction by the analysis over the time period from about 00:00 on March 12th to about 12:00 on March 14th, 2011.

In the May 2011 analysis (Figures 1 and 2), leakage from the D/W was assumed, which is unlikely to occur in reality, in order to simulate this slow PCV pressure increase for the circumstance of only limited information available. The timing of leakage was set as the time when the PCV temperature obtained in the analysis reached the design temperature (138 deg C).

However, leakage from the PCV due to overheating is likely to occur at the gaskets, etc. and the temperature then is about 300 deg C, according to the existing knowledge*2. Leakage from the PCV is unlikely to occur at the timing when the PCV temperature reaches the design temperature (138 deg C). Further, the sharp increase of PCV pressure after about 22:40 on March 14th and stable pressure thereafter at a higher level could not have been reproduced in the analysis.

From these considerations above, there may be scenarios other than leakage which suppressed the PCV pressure increase. The following is the examination results thereof.

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*1 Analysis and evaluation of impacts of the operation records at the Fukushima Daiichi Nuclear Power Station when the Tohoku−Chihou-Taiheiyou-Oki Earthquake occurred (May 23rd, 2011; in Japanese).

*2 K. Hirao, T. Zama, M. Goto et al., ”High-temperature leak characteristics of PCV hatch flange gasket”, Nucl. Eng. Des., 145, 375-386 (1993).

3. Possible causes other than leakage

In the May 2011 analysis, leakage was assumed. If this assumption is excluded, other heat removal mechanisms from the PCV are needed to reproduce the phenomena in which the D/W and S/C pressures were suppressed, while heat was being transferred to the S/C by the RCIC exhaust steam, etc. Specific possibilities are the external sprays, etc. to cool the PCV or sufficient heat release to the environment through heat transfer on the PCV walls. As no PCV cooling operations were conducted over the time period from 00:00 on March 12th to about 12:00 on March 14th, heat removal by heat transfer on the PCV walls could be the mechanism.

The S/C has a doughnut-shaped form and its surface area is very big, but the heat transfer from the surface is considered to be insufficient, since heat transfer by air is limited. If the basement floors of the building were to have been inundated due to the tsunami over the time period of concern, there could be a different scenario: a heat transfer path of the heat transferred to the S/C being further transferred to the water in the torus room from the S/C wall. Heat transfer to water is efficient and therefore sufficient heat might have been removed to prevent the PCV pressure from increasing.

Based upon this scenario, MAAP analysis was conducted assuming that the torus room had been gradually inundated by seawater (with a temperature of about 10 deg C), which finally reached the level of about a half of the S/C elevation. MAAP could roughly reproduce the slow pressure increase from about 00:00 on March 12th to about 14:00 on March 14th. The sharp pressure increase after about 22:40 on March 14th and the increased PCV pressure staying there thereafter could be roughly reproduced in the analysis (Figure 3), by assuming no leakage.

4. Possibility of the torus room being inundated

No statements have been obtained concerning the actual inundation in the torus room. However, it seems possible that the torus room in the lowest floor of the reactor building was inundated because of the tsunami, from the following reasons.

- It has been confirmed that the RCIC cell, turbine building basement floors, etc. were inundated at an early stage after the accident.
- It can be judged from the current water levels in each building that the water was moving through cable penetrations, etc. between buildings.

It is known that the torus room of Unit-4, which has a similar layout to that of Unit-2, was inundated to a depth of about half the S/C elevation (Figure 4). This suggests that the Unit-2 torus room could be similarly inundated like the Unit-4 torus room, although the operating

conditions of the two units differed at the time, i.e., Unit-4 was shut down for periodic inspections, while Unit-2 was in normal operation.

5. Conclusion

The assumption used in the May 2011 analysis that leakage had occurred at the time when the PCV had reached its design temperature can be considered from the design viewpoint not to have actually occurred.

The new analysis, which assumed that the PCV heat had been removed by the water retained in the torus room, could reproduce more appropriately the slow pressure increase from about 00:00 on March 12th to about 14:00 on March 14th, and the sharp pressure increase after about 22:40 on March 14th. It can be considered, therefore, the D/W pressure increase was prevented by the mechanism assumed in the new analysis.

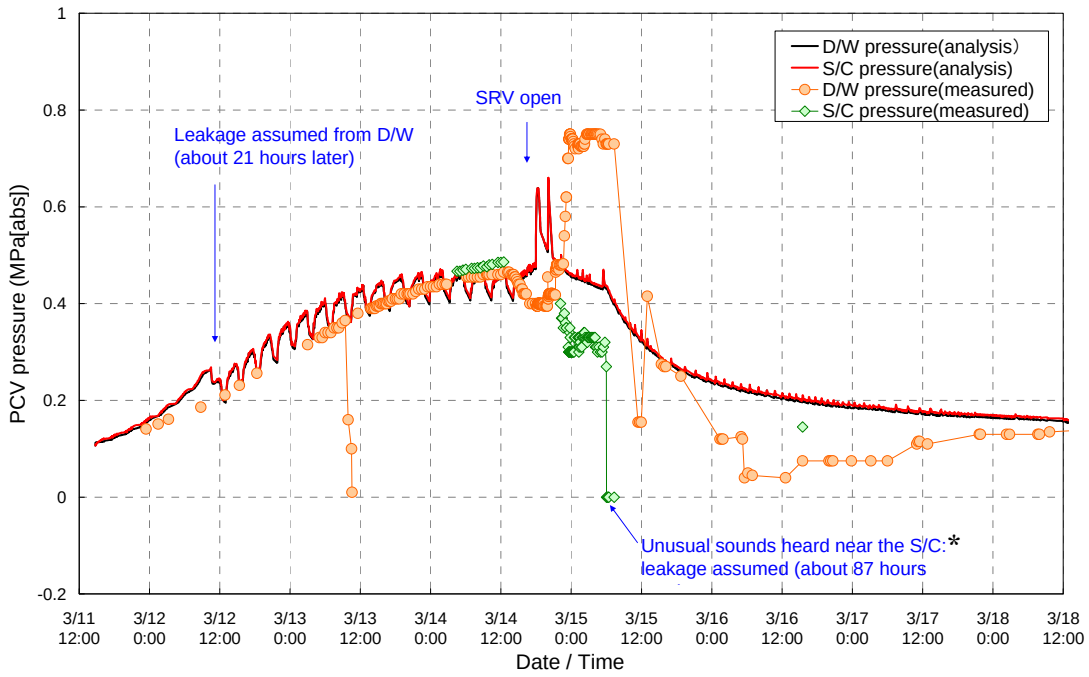

Figure 1 PCV pressure changes at Unit-2

(MAAP results case-1 Figure 3.2.2.3 in the May 2011 report)

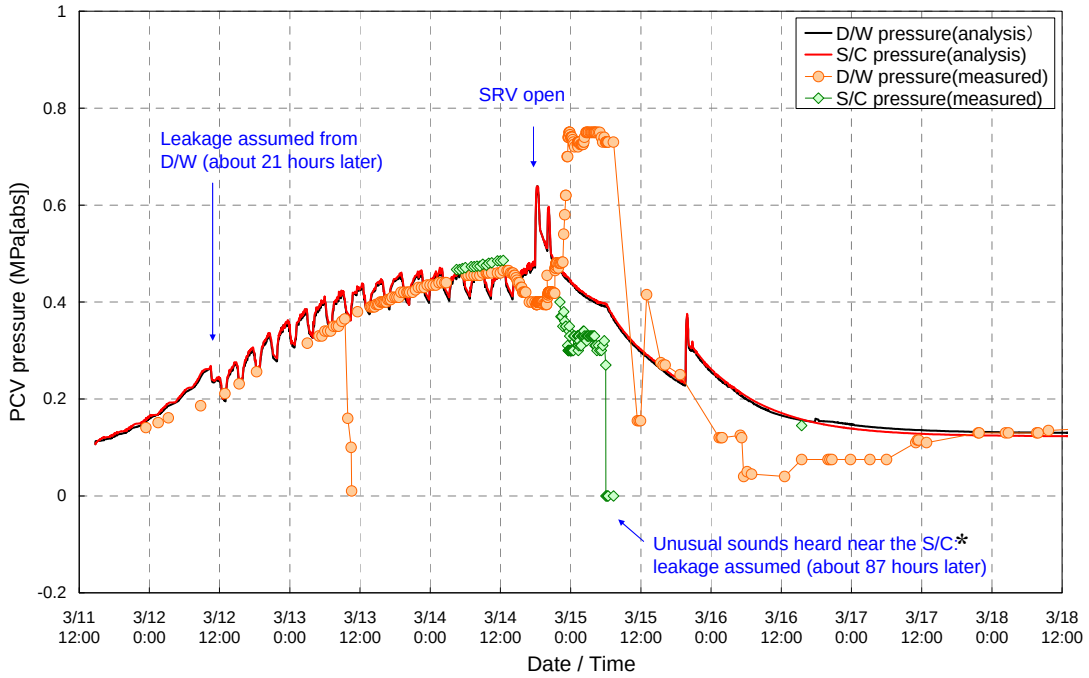

Figure 2 PCV pressure changes at Unit-2

(MAAP results case-2 Figure 3.2.1.2 in the May 2011 report)

*) Note: It is inferred that the unusual sounds was caused by Unit-4 reactor building explosion and not related to Unit-2 S/C.

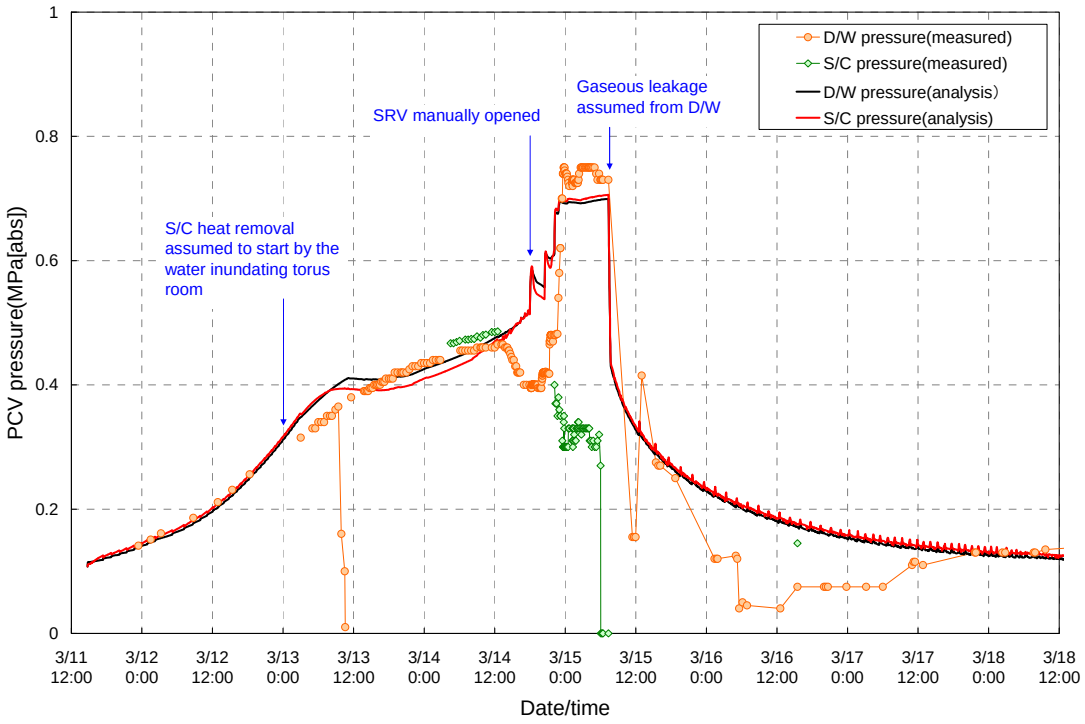

Figure 3 PCV pressure changes at Unit-2 (MAAP results reported in March 2012)

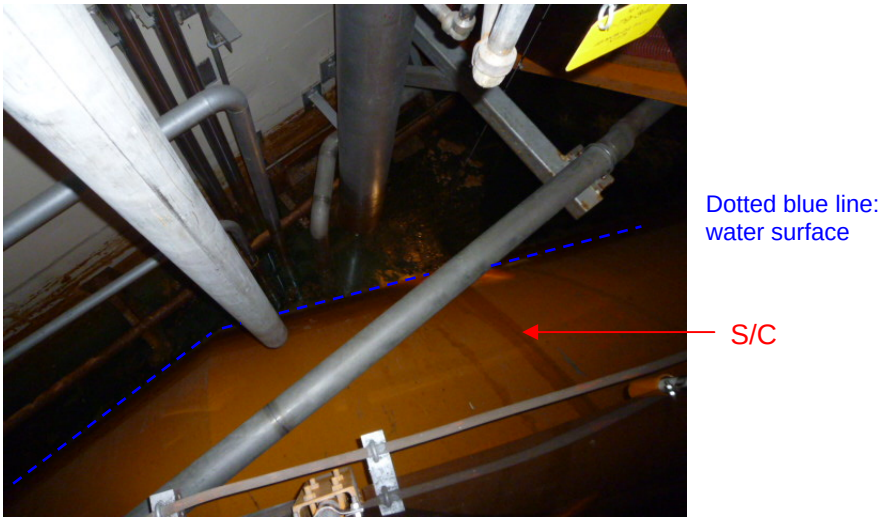

Figure 4 Photograph taken from the Unit-4 torus room catwalk, looking straight down