【Reference】

November 22, 2011

Tokyo Electric Power Company

Evaluation of operating conditions of Isolation Condenser, Unit1, Fukushima Daiichi Nuclear Power Station

As for the Isolation Condenser of Unit1, Fukushima Daiichi Nuclear Power Station (hereinafter referred to as IC), such damages as outflow of coolant from equipment and pipe arrangements outside of the Primary Containment Vessel were not identified in a field survey on October 18, 2011. In addition, as for body-side water level indicating amount of coolant water for IC which was confirmed at the site, 65% and 85% were for System A and B, respectively. This time, we summarized the evaluation of operating conditions of IC based on the said body-side water level as follows:

1. Body-side water level of coolant water for IC

- Figure 1 shows the system configuration of IC. IC circulates steam from Reactor and exchanges heat with body-side coolant water by passing the steam through cooling pipes. By doing this, the steam is cooled and concentrated and is returns to Reactor, results in heat removal from inside Reactor.
- There are the two systems, System A and System B, as shown in the following Figure, and one system consists of four valves (valves for System A: 1A – 4A, valves for System B: 1B – 4B) across the Primary Containment Vessel. Under a normal condition, the 3A valve of System A and the 3B valve of System B are closed, and the others are open.
- Start-up/Stop operation under the normal condition is carried out by switching the 3A or the 3B.
- Compared with the normal water level of 80% and the level confirmed in the filed survey (65% for System A, 85% for System B), it is considered that; as for System A, given the decrease of body-side coolant, it worked at a certain level; and as for System B, since the body-side coolant was not decreased, it worked in a short period.

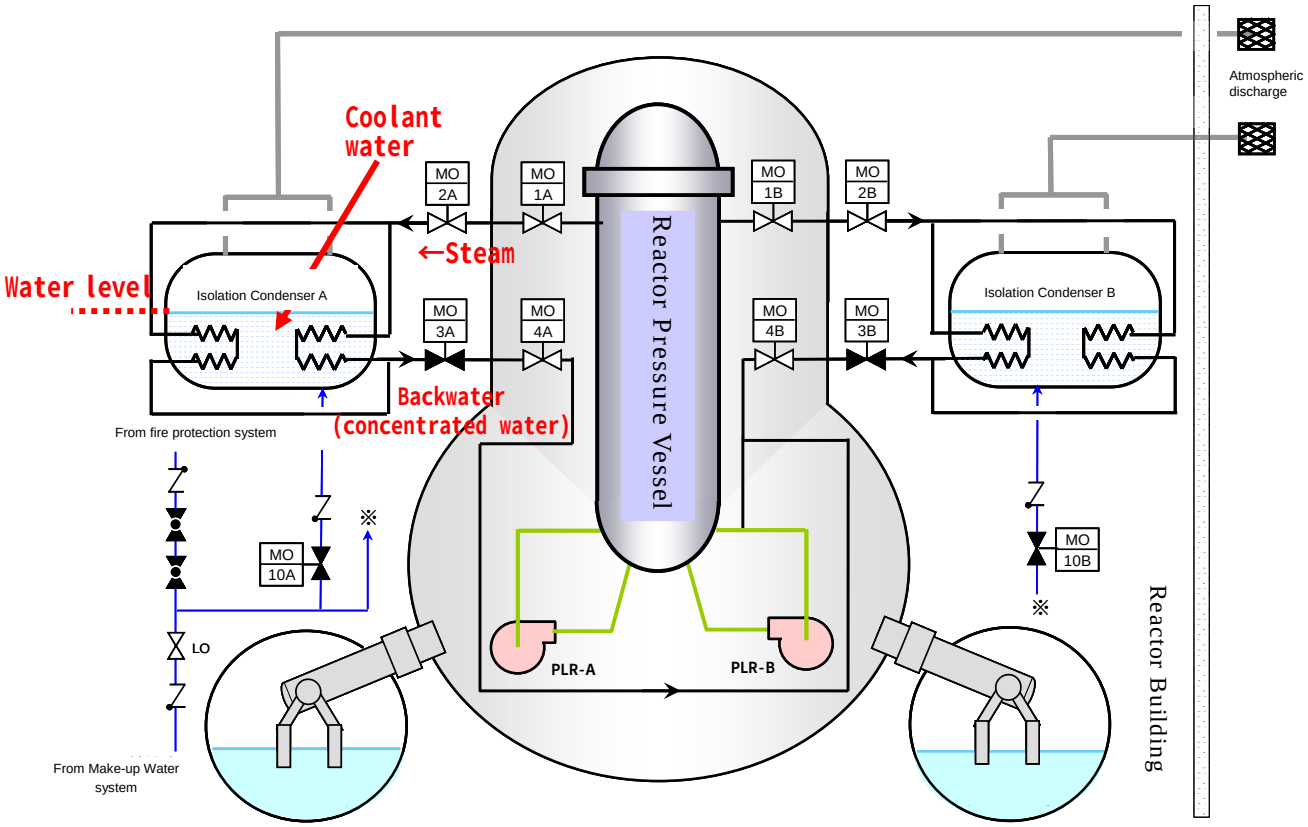


Figure 1：System configuration of Isolation Condenser

2． Evaluation of the water level change of the IC coolant after an earthquake occurrence until Tsunami arrival

After an earthquake occurrence, IC started automatically due to the high pressure in the reactor at 2:52pm on March 11, then it was confirmed that both System A and System B of IC were stopped once by manual operation and reactor pressure was controlled until Tsunami arrival by on and off of only System A according to the data chart of pressure in the reactor and inlet temperature of PLR pump.

(May 24, 2011 pressed)

According to the data chart of IC coolant temperature (May 16, 2011 pressed: showed Pic-2), it is confirmed that the coolant temperature of both System A and System B of IC were increased by heat exchange of steam and coolant. After automatic activation of A-system, it was increased to approximately 70 ℃, then it continued increasing to approximately 100℃ until approximately 3:30 pm when Tsunami arrived. For B-system, after having stopped once after 3:00 pm, it became constant at approximately 70 ℃.

This temperature change in the data chart of the coolant agrees with behavior presumed from the operation results of the IC after an earthquake.

Therefore, coolant temperature of System A IC was increased to approximately 100℃ due to steam injection from reactor because System A had been used intermittently until Tsunami arrival. Coolant temperature of System B IC increased to approximately 70℃ from automatic activation to stop by

manual operation (approximately from 2:52 pm to 3:03 pm)

We think that the heat changed from automatic activation of IC until Tsunami arrival was mainly used to increase temperature of coolant of both System A and System B, and there was little evaporation of coolant with the water level change.

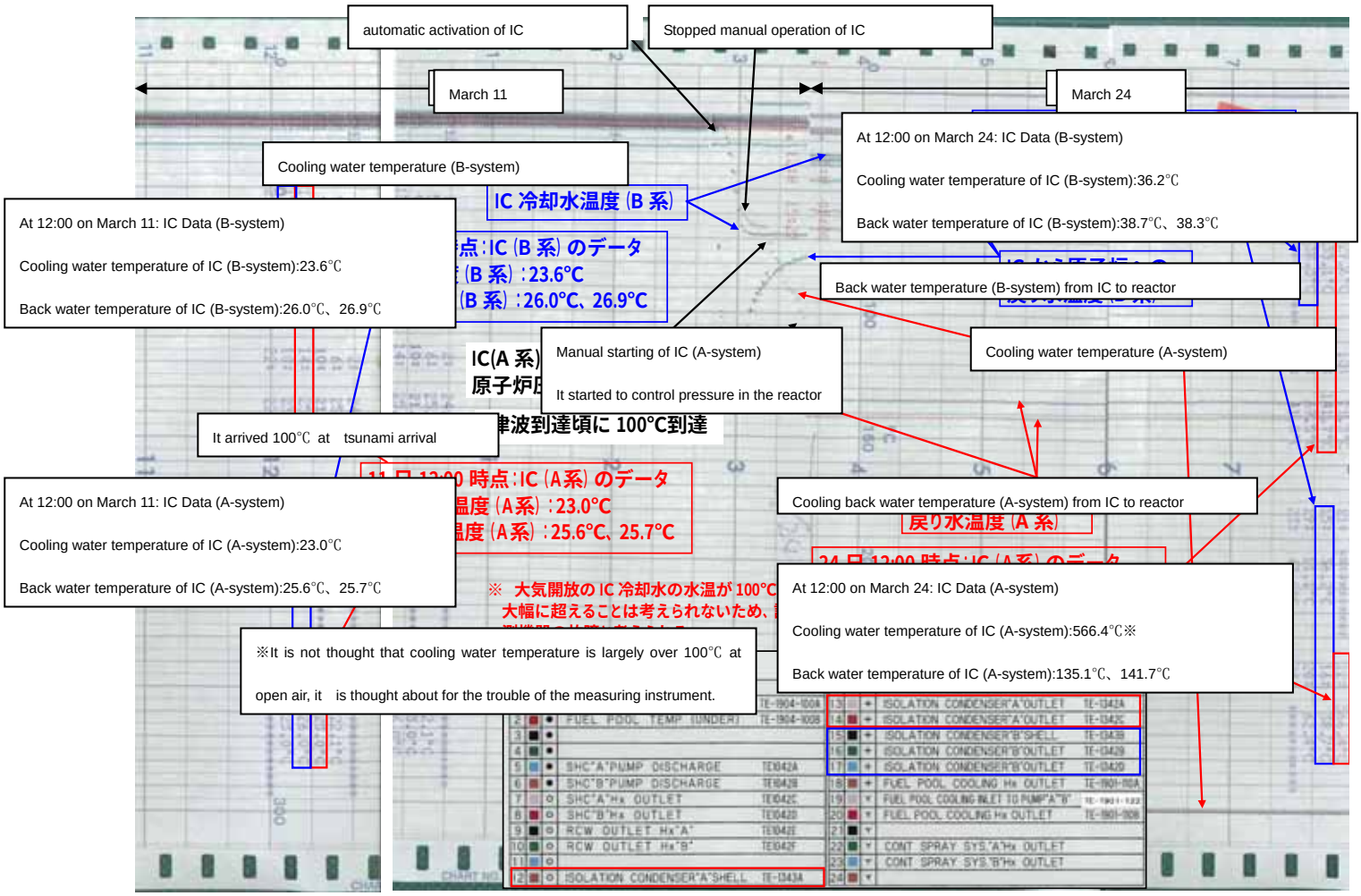


Figure 2：Temperature Chart of IC Coolant (May 16 pressed)

3. Water level change of IC coolant after Tsunami arrived

- As written above, as the coolant temperature of System A increased to the saturation temperature, 100℃ around the time of the arrival of Tsunami, the coolant level decrease at System A was supposed to be caused by evaporation of coolant by heat exchange after Tsunami arrived. What this meant was, valves 1A and 4A located inside the PCV which were supposed to operate to close by the interlock triggered by loss of DC power source were not fully closed, the opening degree unknown although.
- From the investigation result up to now, open operation of valves 2A and 3A located outside of the PCV was conducted and the generation of steam was confirmed.
  - The DC power source lost due to Tsunami temporarily restored and it was found that indicator lamps for valves 2A and 3A was on. As those valves were closed, at 18:18, the operator conducted open operation of valves 2A and 3A and confirmed that steam was generated. After that, at 18:25, the operator conducted close operation of valve 3A. This was due to the following reasons: (i) By the open operation, IC coolant had evaporated but that evaporation stopped. As such, 1A and 4A might be closed by the isolation signal. (ii) The body side water, coolant of IC might be lost by a certain reason. (iii) IC was not working. The water injection line for supply of coolant at the body side was not configured.
  - At 21:30. the operator conducted open operation of valve 3A and confirmed generation of steam. This was due to the following reasons: (i) HPCI pump was in no condition to be relied on. The diesel driven fire fighting pump started. With this, supply of IC coolant could be dealt with. As such, the concern for shortage of coolant lessened. (ii) The indicator lamp for valve 3A was unstable and about to be off. The operator was not certain as to when the next operation of IC could be done.
- Therefore, after 21:30. the status of valves of IC was supposed to be as below:

Table one: open / close of valves at IC

System A	1 A	2 A	3 A	4 A
Open/close	Open※	Fully open	Fully open	Open※
System B	1 B	2 B	3 B	4 B
Open/close	Unknown	Fully closed	Fully closed	Unknown

※ degree unknown

Valves 2B and 3B of System B were confirmed fully closed at the site investigation (Oct 18). As valves 1B and 4B are inside the PCV, we haven't yet confirmed at the work site.

- However, as the coolant level of System A remained at around 65%, the function of IC was supposed to be limited. The reason of this was supposed to be as follows:
  - With overheating of fuel, hydrogen generated by water - zirconium reaction had

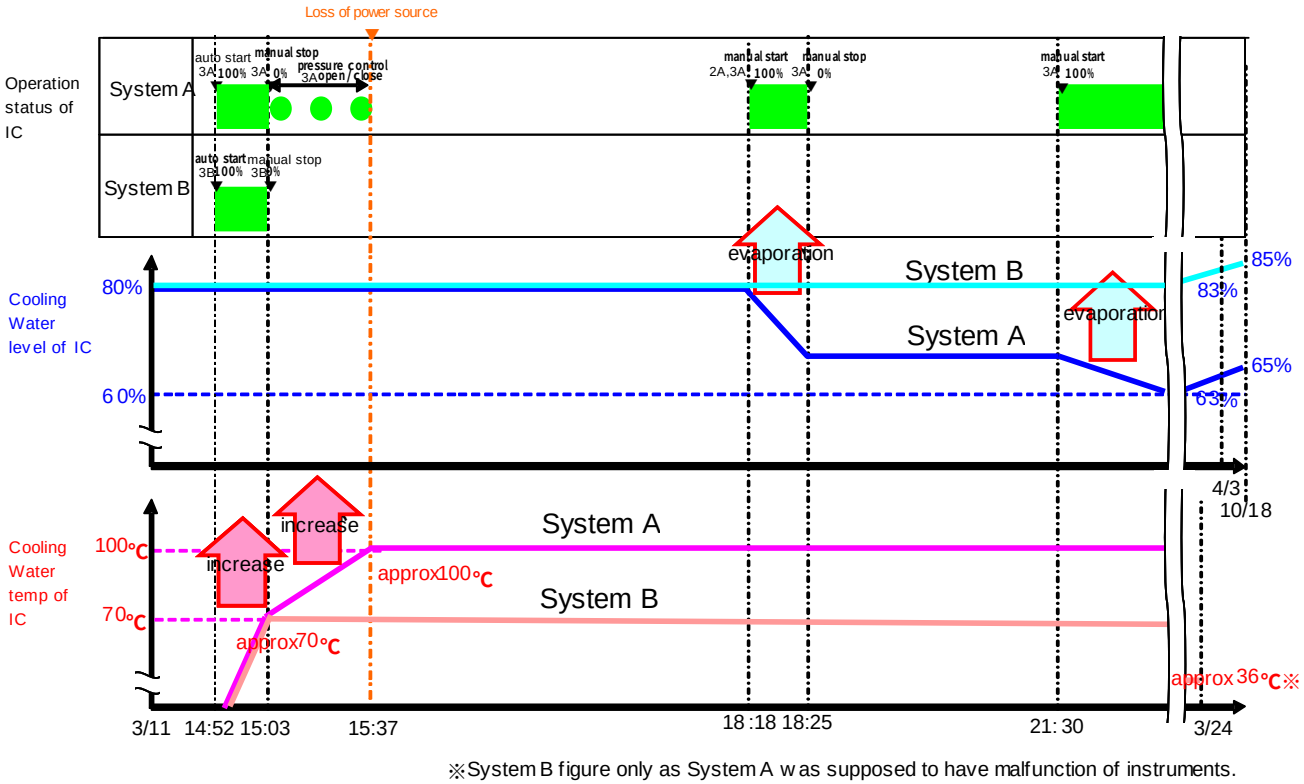
accumulated in the cooling piping of IC and lowered the heat removal function.

- While the exact time is unknown, the Reactor pressure decreased at 3:00 am on March 12 at the latest. With this reduction of pressure, the steam flow generated in the reactor to IC reduced. As a consequence, the performance of IC lowered.

- At “figure 2: temperature recording chart of IC coolant”, after restoration of power source on March 24, data recording resumed. The “returning water temperature from IC to Reactor” of System B was approx 38℃ and the “returning water temperature from IC to Reactor” of System A was approx 140℃. These are supposed to indicate below:
  - As for System B, at least valves 2B and 3B were fully closed. As such, there was no steam inflow from Reactor hence there was no heat source for the returning water resulting in low temperature.
  - As for System A, while the opening degree of valves 1A and 4A in the PCV unknown, as all valves were open, there was slight inflow of steam from Reactor and heated the thermometer.

4. Conclusion

- Between the occurrence of the earthquake and the arrival of Tsunami, coolant of Systems A and B of IC was heated by heat exchange with steam from Reactor and increased temperature. (System B increased temperature during manual stop from 14:52 to 15:30. After that, given the open/close status of the valves, this was supposed to be not functioning)
- After arrival of Tsunami, as for System A, during the time when valves 1A and 4A were not fully closed and valves 2A and 3A were open, coolant of System A evaporated due to the heat exchange with steam from Reactor. The coolant level decreased but stayed around 60%. As such, the function of IC was supposed to be limited.
- The coolant level was 65% for System A and 85% for System B at the time of the site investigation on Oct 18. Just after the occurrence of the earthquake, both System A and System B were bit less than 80% (from data of the transient events recorder announced on May 16). When we checked instruments at Main Control Room on April 3, the level was 63% for System A and 83% for System B. This was supposed to be caused by the gradual instrument error.



※System B figure only as System A was supposed to have malfunction of instruments.

Figure 3: The relationship between coolant level and temp of IC and operation status (image)