Study on Tsunami Preparation at Fukushima NPP – Report 1

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Association for the Study of Failure

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Introduction

The Great East Japan Earthquake on March 11, 2011 triggered the Fukushima-1 nuclear power plant (NPP) accident. The accident destroyed units 1 through 4 and released a large amount of radiation (The Fukushima Nuclear Accident Independent Investigation Commission by the National Diet of Japan reported an equivalent of 900PBq* radioactive iodine). It was rated a Level-7 Major Accident on the International Nuclear Event (INES) scale. Reports[1] have been published about what happened during the accident, however, hardly anything has been said about what preparation against tsunami, the direct cause, would have prevented this accident.

Association for the Study of Failure (ASF), thus, took on the task of finding "what were the minimum set of preparations Fukushima-1 could had taken to prevent the large amount of radiation release," i.e., investigating the "what if …" scenario often said with the Study of Failure[2]. The first meeting took place at Bunkyo Civic Center on April 18, 2015. Two additional members from our association joined the authors and we also invited participation from Atomic Energy Society of Japan (AESJ). Five from ASF and 14 participants from AESJ and other organizations formed the study group of 19. This paper reports major findings from the meeting and discussions that followed.

1. Warnings about tsunami earthquakes

Soeda, in the meeting, had published a book[3] and led the discussion in ASF Forum 124 [4]. The book and the forum had revealed that two government reports, Guideline by 7 Ministries (1997), and "Long-term evaluation" by The Headquarters for Earthquake Research Promotion (2002) had predicted tsunami earthquakes that can generate large tsunami waves even with small tremors. Studies showed that the earthquake predictions could cause tsunami waves of height 15m at Fukushima-1.

2. Power Sources at Fukushima-1

Fukushima-1 had the following power sources.

AC High Voltage (6,900V): For big machines, like Emergency Seawater Pump. Switchboards were metal clads (M/C)

AC Mid Voltage (480V): For in-the-Containment-Vessel (CV) valves for Unit-1 Isolation Condenser (IC). Switchboards were power centers (P/C).

DC Power (125V, 250V): For Unit-1 out-of-CV IC valves, and valves for activating Reactor Core Isolation Cooling (RCIC), High Pressure Core Injection (HPCI), and vent function of Safety Relief Valves (SRV). Switchboards were DC.

In addition, the plant had AC 100V used in regular housing and other DC power sources, e.g., 12Vdc for instrumentation.

3. Waterproofing

We first looked into waterproofing the turbine building that housed the emergency Diesel Generator (D/G), M/Cs, transformers, and P/Cs. The fact that the submerged seawater cooling pumps were unavailable and the large area to waterproof left us without conclusion. Further studies will cover the topic.

4. Securing alternate power sources

RCIC kept cooling the cores for units 2 and 3 even after the Station Blackout (SBO). It kept running for about 3 days for Unit-2, and for Unit-3, about 1 day followed by HPCI that added another day. The problem was the fail-close logic that closed the four valves on Unit-1 IC lines upon SBO.

Figure 1 shows the IC piping and the four valves. All four had to open for IC to work, meaning that IC needed both 480Vac and 125Vdc for it to function.

480Vac: We need to study the availability at the time of a portable 480Vac generator with enough power to drive the in-the-CV IC valves. Also the nitrogen-filled CV disallowed entry to connect power lines directly to the valves. The power would have had to engage the valves power source from outside the CV. Alternatively, a 480Vac power supply vehicle could have hooked up to the P/Cs, one on the first floor of Unit-2 turbine building and 2 on the first floor of Unit-4 turbine building.

125Vdc: This power could have been supplied with batteries. If at least, 125Vdc was available, the operators could have monitored the states of units 1 and 2 and operated several valves. The accident management would have been greatly different.

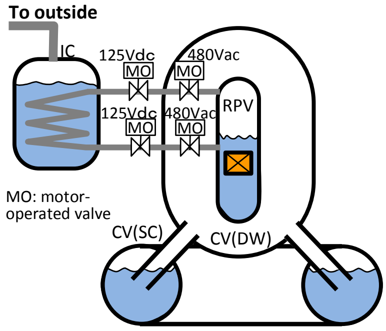

Figure 1 Unit-1 IC

In addition, if the following conditions were met, Unit-1 IC would have likely been available, however, the shortage of discussion time delayed the conclusion to a later date.

- Inside-CV IC valves had "fail-open" logic. Or these valves were not in place.
- Out-of-CV IC vales were directly activated with 125Vdc.

Unit-1, however, had 1 system of HPCI and with 125Vdc, the operators would have recognized the stopped IC and activated the HPCI with choked water flow.

5. Long-term cooling (freshwater and extended operation)

The above discussion revealed that only if 125Vdc was available, the plant would have survived a few days after the tsunami. Further procedures then were Reactor Pressure Vessel (RPV) venting with SRV vent function (by energizing 125Vdc solenoid valves to supply nitrogen gas to lift the valves open) and long-term cooling with cooling water from outside. The plant further needed to secure freshwater and keep the cooling functions running. During the actual accident, they used freshwater in the fire pool which only lasted for less than 10 hours and then they had to inject seawater. Using seawater for cooling the RCIC or injecting it into the reactor has concerns with erosion and salt disposition. A large source of freshwater like, dam, tank, or reservoir would have helped but again, details will be discussed in later meetings.

6. Open problems and summary

This first meeting left some open problems like,

- Feasibility of waterproofing
- Portability of 480Vdc power source
- Availability of Unit-1 IC upon SBO
- Extended long-term operation of cooling systems

In summary, Fukushima-1 would have survived for several days after the tsunami with only 125Vdc batteries to avoid a severe accident. The long-term severe accident prevention is a subject to evaluate in our coming meetings.

References

1 Report by Investigation Committee on the Accident at the Fukushima Nuclear Power Stations, July 23, 2012 [http://www.cas.go.jp/jp/seisaku/icanps/eng/]
Others include the National Diet, TEPCO, and K.Omae reports

2 Minutes from the 4th Special Meeting of Japan Atomic Energy Commission, Cabinet Office of Japan [in Japanese] [http://www.aec.go.jp/jicst/NC/iinkai/teirei/siryo2015/siryo08/siryo3-2.pdf]

3 NPP and Tsunami, Who buried the warnings, Takashi Soeda, 2014, Iwanami

4 Urgent Forum 124 "What are ordinary people in general," ASF[http://www.shippai.org/shippai/html/index.php?name=news823]

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a: Japan System Safety Lab, b: Komatsu, c: SYDROSE LP

*: PBq peta becquerel. 10^{15}Bq