

TEPCO's Nuclear Power Plants suffered from big earth quake of March 11,2011

Follow up prepared at 8am of March 16 in
Vancouver Canada (1am of March 1 in Japan).

Yoshiaki Oka

Waseda university

Prepared in Canada for the presentation at ISSCWR5 on March 14, 2011 from the request of the organizers. Available Information is very limited. Recovery action is in progress. The presentation may contain misunderstandings.

The big earth quake

- Attached northern part of Japan at 2:46pm of March 11, 2011.
- Magnitude is 9 in Richter scale. The biggest in history.
- Some earthquakes occurred along the boundary of plates. Hundreds of km of the boundary moved, similar to the big earthquake in Indonesia.
- Big Tunami (10m) attacked northern Japan and NPP (nuclear power plant). It was bigger than expected.
- There is no damage in the central Tokyo.
- Nuclear power plants were automatically shut down at the earthquake.

Tepco Fukushima site 1 (1F)

Loss of ultimate heat sink

common cause failure

- 6 units: 4units (1F1-4) and 2units (1F5,6), separated between 100m
- Tsunami damaged ultimate heat sinks (sea water pumping and cooling system), common cause failure
- Without ultimate cooling, Emergency DG, ECCS and spent fuel pool cooling do not work for long time.
- Beyond design basis accident (severe accident)
- Emergency procedures such as sea water pumping, area evacuation were taken.
- Emergency power lines may have cross-tie between the units (maybe among 1F1-4, 1F5,6) ,Emergency DG of 1F6 looks not damaged by the earthquake.
- Availability of external power (off-site power) is not known (Once lost at the earthquake)

Fukushima site 1 (1F)

- 6 units , Unit #1, #3 and #2 in trouble. Unit #1: 460MWe BWR ,Unit #3,#2: 768MWe BWR
- 2:46pm March 11: The earth quake happened. Plants automatically shut down. Offsite power lost. Emergency DG started up.
- 3:41pm Emergency DG(diesel generator) stopped due to loss of equipment cooling water. (Tunami was bigger than expected.) **All AC power was lost** and consequential isolation from UHS(ultimate heat sink), except for IC (isolation cooling system) in 1F1. RCIC(reactor core isolation cooling sytem) in 1F **2**
Blackout + (mostly) loss of UHS
- RCIC was available to makeup water in the initial stage.
- SAM (Severe Accident Management) prepared in the 90's in place such as containment scrubbing venting, supply of water from portable water tank using Fire Protection pump or Fire Engine and inter-connection of power supply with other units.
- Site emergency announced. (After JCO criticality accident, emergency law was settled. It requires report to the central government.) Evacuation up to 20km (completed on March15) and stay in the house between 20- 30km around 1F, 10km around 2F.

Summary of Site #1, Unit 1 and 3

- Loss of All AC power.
- Partial core uncover (1-2m) occurred.
- Hydrogen generated by Zr-water reaction (oxidation of fuel cladding tubes at high temperature of the uncovered fuels.)
- CV pressure increased and CVs were vented to maintain the integrity.
- Hydrogen detonation occurred in the upper part of the reactor buildings (unit 1 on March 12 and unit 2 on March 14). 14 workers injured.(the CV sits below 2m thick concrete structure and not damaged by the detonation)
- Area evacuated in 20km.
- **Radiation levels are low**, 1mSv/h highest at the site. (Dose limit of public: 1mSv/y) on March 13.
- Sea water with boric acid injected into RPV and CV.
- CV integrity is maintained. **Large release will be not likely.**
- Cores are covered by water now.
- High radiation dose, 400-100mSv/h was observed on March 15 . It maybe be the radiation from the contaminated walls fallen on the ground by the detonation.
- **Fraction of fuel damaged are estimated 70%(1F1) on March 15.**
- Level 4 accident of IAEA.

Fukushima site #1 Unit 2 (1F2)

- Loss of all AC power.
- RCIC was in operation but is now lost.
- Low water level in RPV and High CV pressure continued. Mobile power supply was tried but not working well.
- Seawater injection were conducted.
- Nuclear fuels were fully uncovered by water for 2 hours at 6:30pm of March 14 due to the lack of oil of the pump injecting sea water. The fuels were covered with water again, but fully uncovered at 11pm of March 14 due to the increase of RPV pressure from the closure of depressurization valves.
- The reactor building wall was partly removed, not to accumulate the hydrogen at CV vent. There will be no risk of hydrogen detonation on the top of the reactor building as unit 1 and 3.
- But hydrogen detonation occurred in the CV. Leakage from the CV is likely.
- Estimated fraction of damaged fuel is 33% on March 15.
- Putting water into RPV and CV is necessary. Need to cover the rapture with some materials.

1F unit4 (1F4)

- It was not in operation for annual inspection at the earthquake.
- Hydrogen detonation occurred on March 15 in the top of the reactor building and fire was observed (Extinguished now). **All fuels of 1F4 stayed in the spent fuel pool for the annual inspection.** The hydrogen is generated by radiolysis of water in the spent fuel pool due to loss of external power and loss of UHS. If fuels are uncovered, hydrogen will be generated by Zr-water reaction .
- Spent fuels: risk of uncover, radiation dose increase if water level decreases.
- Fire were observed on March 15 and 16 on the top floor of reactor building, but not continued.
- **Need to supply water into the pool (ordered to TEPCO by minister of METI)**

1F5,6

- 1F5 safe shut down, but water level of RPV decreased slightly.
- 1F6 have Emergency DG without damage of Tunami. The DG is used to supply water both 1F5 and 1F6.

Fukushima site # 2 (2F)

10-20km from site #1

- 4 units: 1100MWe BWR
- Sea water pumps of unit 1,2 and 4 did not work due to Tunami. The motors were being replaced unit by unit. Recovery of the cooling were successful for unit 1 at 3am and for unit 2 at 7am of March 14. The coolant temperature decreased to 100 in Celsius (C) at 4pm. The reactors of 2F were stabilized.

Radiation levels and radio activities

- The highest radiation dose reported at site boundary was 15mSv/h of 1F. Dose limit of workers, 50mSv/y.
- Many monitoring posts around the area.
- The radioactive materials released may be mostly inert gas FP and volatile FP. Inert gas will not accumulate.
- If some iodine are released, intake of the contaminated milk need to be prevented to avoid thyroid cancer of children.
- Prediction of radioactivity distribution is possible by the computer code.
- Rain carries airborne radioactivity on the grounds.
- Jet stream will carry radioactivity to the east (Pacific ocean), if it is carried high in the air. Hydrogen detonation may not reach high, 500m maximum? Recirculation of eco system will carry up to clouds.
- If steam explosion of core melt occur, large amount of FP in the fuel will be carried into the air. It looks not yet happened. BWR RPV is large in diameter and power density of BWR is half of PWR. If melted core is contained in RPV, the release of FP will be not large. In vessel retention?
- There is a domestic flight rout near the site. Rout change is ordered.
- We observed the radioactivity of nuclear bomb testing in the air frequently 20-30 years ago.