The Results of a Safety Investigation into the Accident at Tokyo Electric Power Co.'s Fukushima Dai-ichi Nuclear Power Station

September 16, 2011
Nuclear and Industrial Safety Agency

1. Investigation Overview

Objective: A hearing was conducted with relevant parties at Fukushima Dai-ichi NPS in order to gain a full understanding of the state of response at the time of the accident onset.

Period: August 2011

Subjects: The plant manager and others

2. Investigation Results

The state of response by Tokyo Electric Power Co. at the Fukushima Dai-ichi NPS at the time of the accident onset is as follows, as determined by Nuclear and Industrial Safety Agency in the course of this safety investigation.

N.B. There exists a possibility that further investigation will reveal new facts.

(1) General outline

1) Structure

Personnel designated for call-up as a part of nuclear emergency response (approximately 400 employees) were successfully mustered. The nature of the emergency, with multiple plants being impacted simultaneously, meant that in addition to their predetermined roles, personnel had to conduct a variety of responses. In particular, the urgent work of restoring power and instrumentation had to be led by TEPCO employees under extremely difficult circumstances, in part due to the withdrawal of most of the workers from assisting partner companies, such as component makers, from the power station.

The seismic-isolated building a short distance away from the plant served an important purpose as the emergency response

headquarters, but it cannot be described as an environment adequate to the task, in terms of providing the workers stationed there with sufficiently-sized space, as well as other needed resources.

2) Communication within the plant

Communication within the plant was severely limited by the loss of all AC power (see below). As a result, the emergency response headquarters was hampered in its efforts to acquire a timely and proper grasp of the plant situation and to plan a response based on these.

Examples:

- The power loss rendered the transmission sources for plant parameters and other data non-operational. As a result, there was no data to display even though the system for supplying these data to the emergency response headquarters, the Safety Parameter Display System (SPDS), was operating on emergency power.
- On-site PHS was non-operational.
- The only means of communication between the main control room and the emergency response headquarters were the hotline and landline telephones.

3) Procedures and manuals

Severe accident measures did not assume simultaneous response to multiple plants or loss of all AC power. Responses that were not a part of the accident management manual, such as reactor injection using fire engines, were improvised. Venting was also performed adaptively, on the spot (manually turning the vent valve handle, connecting tanks and pumping in compressed air). The facilities used for severe accident response need to be evaluated for reliability, especially given that there are no regulatory requirements.

4) Inhospitable environment

Restoration work did not proceed smoothly due to

inhospitable work environment, such as flooding due to the tsunami, ongoing aftershock, darkness due to power loss, and high radiation dose and profusion of rubble following the explosions.

Related information:

- Tsunami situation in Fukushima Prefecture

  March 11 14:49 Major tsunami warning issued

  March 12 20:20 Downgraded to tsunami warning (Lifted at 17:58 on the 13th)

- Aftershocks in Fukushima Prefecture

  (Seismic intensity in Japanese scale)

  March 11

  Max 6+: 1 (the main shock)

  Max 5+: 1

  Max 5-: 4

  March 12

  Max 5-: 1

(2) Specific responses

1) Restoration of power

Power restoration was undertaken using power supply vehicles, in order to operate systems (in particular standby liquid control [SLC] system for borated water injection) capable of high-voltage injection into the reactors. The overview is as follows.

- Following the tsunami impact, damage assessment was conducted on equipment including power distribution panels, and most of the panels were determined to be unusable. During this time, requests for power supply vehicles were also being made to multiple sources.
- A series of power supply vehicles began arriving through the night of the 11th to the morning of the 12th, from Tohoku Electric Power Co., the Self-Defense Force and TEPCO.
- Cables were procured from assisting companies, and link-up operation to the Unit 2 power distribution panel (P/C 2C) began in the early hours of the 12th. The work proceeded until approximately 15:30 that day, with the SLC pump connected

and water injection into the reactor about to start. At that point, an explosion took place in Unit 1 (15:36 on the 12th), damaging the cable and bringing the power supply vehicle to automatic shutdown.

2) Alternative water injection using fire extinguishing system

- Because much of the emergency cooling systems, with the exception of isolation condenser (IC) and the reactor core isolation cooling system (RCIC), went offline due to the loss of all AC power, exploration into the possibility of core cooling through fire extinguishing system and fire engines was begun around 17:00 on the 11th.
- Accident management plans assumed reactor injection using diesel-powered fire pumps. However, in this accident, preparations were also begun for an improvised injection using fire engines, due in part to some of the fire pumps being rendered unusable.
- The plant had 3 fire engines, but only 1 could be used on the Units 1-4 side immediately following tsunami impact. One engine was damaged by the tsunami, and another was on the Units 5-6 side, and could not be moved near units 1-4 until the early morning of the 13th.
- Fire hydrants, some spraying water, were unusable as a water supply, and the filtrate tanks (2 tanks with 8000kL each) were also out of commission due to leaks. Fire cisterns for each Unit were used as water supplies. However, the capacity of the cisterns is in tens of kiloliters, limiting their utility as sources for freshwater injection.
- There was no hesitation in using seawater for injection, since reactor cooling was the top priority.

Specific efforts at each Unit are as shown on Attached Sheet 1.

3) Venting

- Accident management plans assumed the availability of power and therefore the ability to open and close vent valves

from the main control room. However, in this accident, circumstances necessitated operations such as workers actually entering the area, manually turning the vent valve handle, connecting small generators to induce magnetization, and pumping in compressed air using tanks and other equipment.

- Vent valves that require air pressure to open proved difficult to keep open, with repeated changes of air tanks being needed to re-open the valves.

Specific efforts at each Unit are as shown on Attached Sheet 2.

4) Unit 1 emergency isolation condenser (IC) operation

- Following tsunami impact (around 15:30), the status of the isolation valves on both A and B condenser (IC) systems became unavailable. Around 18:00, the main control room confirmed a “closed” indicator lamp for just the one system A isolation valve outside the PCV. From this, it was judged that the battery had come back online and the IC was operational. The valve was switched open at 18:18, and steam was confirmed.
- However, steam could no longer be confirmed soon after, and the valve was switched closed at 18:25. At 21:30, the IC was once again switched open.
- The emergency response headquarters inside the NPS believed that IC was continuing to operate through the tsunami impact, due in part to information that the reactor water level was above the TAF.

  (However, according to the accident report submitted by TEPCO to METI on September 9, the extent to which the IC was functional cannot be determined at this point, given that the IC circuit examination conducted by TEPCO indicates that the status of the isolation valve inside the PCV is unknown.)

5) Hydrogen leak response

- Prior to the explosion at Unit 1, the possibility of hydrogen explosion in a reactor building had not been discussed. There was some expectation that hydrogen would be generated through water-zirconium reaction, but it was believed to remain inside the PCV.
- Following the explosion in Unit 1, hydrogen countermeasures at other units were explored. Measures proposed included boring holes in the reactor building ceiling, and opening the blow-out panels. Because boring holes required heavy machinery, it was judged to be impractical in the light of ongoing aftershocks. Opening the blow-out panels also proved difficult, given the limited access to the interior of the reactor building due to high radiation dose. Unit 2 was judged to have had its blow-out panels opened by the Unit 1 explosion. Holes were bored in the ceiling of Units 5 and 6 buildings on March 18.

6) Future Response

- The understanding gained through this investigation will be utilized to acquire an even fuller grasp of the realities of the Fukushima Dai-ichi NPS accident, such as an understanding of the state of seismic and tsunami damage to buildings and equipment. In addition, NISA will continue to engage these issues through safety investigations and other means, as a part of the accident investigation.
- This information will also be utilized as the basis for reassessing safety regulations such as safety standards and disaster prevention measures, a process which is currently being explored.