VII. Situation regarding Radiation Exposure

1. Situation of radiation exposure concerning radiation workers and other related workers

(1) Dose limit for radiation workers

1) Provision of dose limit prior to the accident

Regarding the dose limit, etc., the Radiation Review Council established in the Ministry of Education, Culture, Sports, Science and Technology (MEXT) has studied recommendations made by the International Committee on Radiation Protection (ICRP) and its possible application in Japan, in which it has recommended its views. Under the relevant laws, based on the ICRP 1990 Recommendations (Pub. 60), the dose limit for radiation workers is set at an effective dose of 100 mSv over 5 years and 50 mSv per year. In addition to this limit, the dose limit for women is regulated at 5 mSv over 3 months.

The dose limit for radiation workers engaged in emergency work is regulated by the relevant laws at 100 mSv for an effective dose, at an equivalent dose of 300 mSv for optic lenses, and at an equivalent dose of 1 Sv to the skin.

2) Revision of dose limit in emergencies based on the accident

In consideration of the situation of this accident, the dose limit for radiation workers in emergencies has been revised due to the need for work in preventing further worsening of the nuclear disaster. In the areas where emergency measures to combat the nuclear emergency were implemented from the day when the Declaration of a Nuclear Emergency was issued according to the Act on Special Measures Concerning Nuclear Emergency Preparedness until the day when the Declaration of Cancellation is issued, the effective dose of 100 mSv was raised to 250 mSv in the event of an unavoidable emergency, which took effect on March 14. In determining the basis for the 250 mSv dose limit, the ICRP 1990 Recommendations (Pub. 60) that stipulate a dose limit of 500 mSv for persons voluntarily engaged in emergency rescue operations in order to avoid definitive impact, a primary objective of radiation protection, was taken into consideration.

In revising the dose limit, the President of the National Personnel Authority, the Minister of Health, Labour and Welfare, and the Minister of Economy, Trade and Industry

consulted the Radiation Review Council established in MEXT on the revision of the dose limit, based on the Act on Technical Standards for the Prevention of Radiation Disasters, and obtained the opinion that such a revision was appropriate.

Furthermore, the Ministry of Health, Labour and Welfare (MHLW) has issued documents for administrative guidance on radiation doses for workers previously engaged in emergency work and have hence been engaged in other work than that of emergency work which nevertheless exposes them to radiation. (Attachment VII-1)

(2) Radiation control measures in nuclear power stations

1) Radiation control measures by the operator (Tokyo Electric Power Co. Inc. (TEPCO)) prior to the accident:

TEPCO had been performing radiation control measures for the purpose of minimizing radiation doses received by workers by assessing the radiation levels in the "radiation controlled areas" such as the reactor buildings and turbine buildings, and by confirming individual radiation operational plans for each operation. In addition, only personnel confirmed by TEPCO as being designated and registered as radiation workers and granted proper permits were able to work in the controlled areas.

Normally, at Fukushima Dai-ichi NPS, a system was established and employed so that each worker was provided with an Alarm Pocket Dosimeter (APD) and wore it to measure radiation doses at work and ensured that each worker was identified when entering a control area. The dose of the APD was read after completion of the work and was automatically recorded, so that calculations for a worker's individual daily dose, or doses by an individual company, or by total individual doses per month, per year, etc. could be obtained.

Furthermore, when entering and leaving a controlled area (in each building), dose readings were taken in the building next to the entrance of each building, as well as when putting on protection equipment and an APD just before entering a controlled area.

Regarding internal exposure control, TEPCO conducted measurements and evaluated all workers using a whole body counter (WBC) when they first entered the radiation controlled areas and also once every three months.

2) Radiation control measures by the operator after the accident

a. Measures to control individual external exposure:

a) System of radiation control measures at Fukushima Dai-ichi Nuclear Power Station:

In this accident, tsunamis reached buildings facing the sea coast which provide access to the controlled areas as described in (2), depriving the function of the control system, and rendering many of the APDs and dose reading devices unusable as they became submerged in seawater.

Also, due to the increase of radiation and contamination levels in the power station site, it was decided that workers should conduct all operations in TEPCO's response headquarters established in the quake-proof building, and that distribution of APDs and recording of doses were performed in the quake-proof building.

From March 11, shortly after the earthquake, dose management for workers had to be performed manually by recording the names of individuals and their daily dose values on paper to accumulate data. Moreover, such daily individual doses which were manually recorded were and are manually input into PCs (using Excel sheets) and saved in a database.

Since many APDs became unusable for the reasons described above, not every worker was able to wear an APD and TEPCO has thus been managing radiation doses of all the personnel by making leaders of operational groups wear APDs on behalf of the entire group. As controlling workers' radiation exposure is extremely important to ensure safety on the site, the Nuclear and Industrial Safety Agency (NISA) gave oral instructions to TEPCO to make every effort to manage its workers' radiation exposure and dose. After receiving these instructions, TEPCO procured the necessary dosimeters by April 1 so that all the workers conducting operations were able to carry portable dosimeters.

Furthermore, the evaluation of external exposure during work in the quake-building was based on the length of period of stay because workers didn't wear APDs when working inside the building. Moreover, shortly after the earthquake, appropriate protection equipment such as protective masks were not worn even though the calculation of radioactive materials within the air of the quake-proof building exceeded the allowable limits of radioactive concentration in the air, resulting in

workers staying in the building inhaling radioactive materials.

On April 14, about one month after the accident occurred, radiation control measures similar to that of the previous dose management (the system in which individual names and dose readings are automatically recorded) became available since the system of radiation control measures was nearly completely restored.

b) System of radiation control measures in J Village

Shortly after the accident from March 17, J Village, a soccer training facility located at a point about 20 km south of Fukushima Dai-ichi NPS, was utilized as a place for preparing workers for entry into Fukushima Dai-ichi NPS, where they put on their protective equipment, and performed decontamination tests when leaving, etc.

A system was established for radiation workers in Fukushima Dai-ichi NPS who don't go through the quake-proof building to attach ADPs (there are several kinds of dosimeters due to hasty procurement and assistance received from a variety of organizations) at J Village before going to work at the site in Fukushima Dai-ichi NPS, and to record doses for the day when returning dosimeters upon finishing work for the day. For this reason, dose readings in J Village continue to be manually calculated since the beginning of the accident. TEPCO is planning to introduce an individual recognition system using bar codes in J Village from early June.

b. Wearing of radiation protection equipment, work management, etc.

Due to the high concentration of radioactive materials over the entire site of Fukushima Dai-ichi NPS, TEPCO requires workers to wear Tyvek and other protection clothes, gloves, and protection masks. It also requires appropriate protective clothes (anoraks, etc.), rubber gloves, and shoe covers taking into consideration weather conditions and contamination levels of the work sites.

As for the quake-proof building, it was difficult to prevent the inflow of radioactive materials because the entrance door was not an airtight structure, and the door was slightly damaged by the hydrogen explosions of Units 1 and 3, leaving a gap by the hydrogen explosions of Units 1 and 3, and as there no particular protective equipment installed in the building in the event of such an accident, the inhalation of radioactive materials by

workers occurred. Countermeasures were taken to decrease the concentration of radioactive materials in the air of the building such as connecting a unit house installed with an ambient air filtration system with charcoal filters at the entrance of the quake-proof building. As a result, the concentration of radioactive materials has been kept at low levels to the extent that it has been unnecessary to implement further protective measures.

In addition, a preliminary survey is conducted so that workers are informed of the situation in developing a work plan in areas such as high radiation areas.

(3) Status of radiation exposure

The status of exposure doses for the workers engaged in emergency work at Fukushima Dai-ichi NPS as of May 23 is that there were approximately 7,800 people who entered the site and were exposed to approximately 7.7 mSv on average. Thirty people were recorded as receiving doses over 100 mSv. The compiled results of exposure doses are as shown in Attachment VII-2.

In this accident, there are cases where exposure doses exceed the limit dose stipulated in the law, and the details are as follows.

On March 24, it was confirmed that two out of three workers involved in work for laying electric cables on the 1st and basement floors of the turbine building of Unit 3 had radioactive materials attached to the skin of their feet when stepping into puddles of radioactive water wearing low-cut shoes. Although TEPCO decontaminated their exposed skin, it decided that there was a possibility of beta ray burns, and the two workers were transported to Fukushima Medical University Hospital. After examination on March 25, all three workers including the two that were exposed to the puddle were transported to an independent administrative institution, the National Institute of Radiological Sciences (NIRS). Immediately after their arrival, NIRS performed checkups, etc. The workers were also re-examined on April 11 for follow-ups and it was confirmed that these three workers were not suffering any health issues. From the results of the evaluations of the equivalent doses of their skin, it is estimated that they were exposed to less than 2 to 3 Sv.

Moreover, on April 27, in the course of confirming radiation exposures over a period of three months, TEPCO confirmed that a female employee had been exposed to more than 5 mSv over

a period of 3 months, which is above the legally stipulated dose limit. Meanwhile, some of the people engaged in work were not designated as radiation workers.

For this reason, NISA gave a strict warning to TEPCO, and instructed it to investigate the cause of the exposure, to develop measures to prevent any recurrence, to verify the system of radiation control measures in Fukushima Dai-ichi NPS, and to develop appropriate countermeasures based on their findings. Following the instruction on May 2, TEPCO submitted a report. NISA received the report, and responded with a view to implement appropriate radiation control measures for radiation workers to ensure their occupational safety and health management, by issuing an instruction to TEPCO on May 25 ordering it to strive to further improve its measures and to perform appropriate radiation control measures for radiation workers and observe safety regulations at Fukushima- Dai-ichi NPS and Fukushima Dai-ni NPS. (Attachment VII-3)

Also, the government has issued instructions to TEPCO regarding (i) exposure dose management for workers, including internal exposure, thorough implementation of temporary health examinations, etc. as decided in the "Policy for Immediate Actions for the Assistance of Nuclear Sufferers" by the Nuclear Emergency Response Headquarters on May 17, and has made it a rule to require it to periodically report its implementation status. In addition, (ii) certain emergency operational works are required to be reported in advance to the Labor Standards Inspection Office to have their exposure control for workers, etc. confirmed.

Moreover, the policy requires (iii) creating a database capable of tracking exposure doses , etc. over the long-term for all the workers engaged in emergency work even after they leave their current jobs, and conducting long-term health management. On May 20 the MHLW established the "Promotion office for the measures for the health management etc. of workers of Fukushima Dai-ichi Nuclear Power Station" to promote the measures from (i) to (iii).

Besides radiation control measures, as it is important to establish and maintain the working environment of workers, TEPCO is working to improve the occupational safety, health management and the living environment for workers at Fukushima Dai-ichi NPS and Fukushima Dai-ni NPS.

(4) Radiation control measures for employees of the national government engaged in restoration works, etc.

1) Radiation control measures for the Self-Defense Forces of Japan

Self-Defense Force members working within 30 km of Fukushima Dai-ichi NPS estimate their expected exposure dose in advance from the latest monitoring results in the planned activity area or neighborhood and planned time of the activity, and take necessary appropriate measures such as wearing simple protection clothes (Tyvek) and so on.

The SDF members also monitor their exposure using dosage meters and confirm their cumulative dose during their active duty. The upper limit of the cumulative exposure dose for an individual member is 50 mSv (the limit for exposure of radiation workers), but for female members, it is 5 mSv over a 3-month period, and if there is a possibility that exposure will exceed 30 mSv (or 3 mSv for female members) during their activity, members temporally suspend their activity considering a turn back dose for returning (a dose capable of returning within the limit of cumulative exposure dose).

For emergency and other unavoidable lifesaving operations, the upper limit of the cumulative dose is 250 mSv (excluding female members).

As of May 31, there is no SDF member whose exposure exceeds the above mentioned limit.

2) Radiation control measures for fire fighting teams

Fire fighting team members working within 20 km of Fukushima Dai-ichi NPS put on equipment such as simple protection clothes, and measure the air dose rate and cumulative dose during their operations to minimize the exposure doses as much as possible, with the upper limit having been decided by individual Firefighter Headquarters, taking into account the exposure dose limit in the Operation Measure Manual of the Fire and Disaster Management Agency.

The Manual sets the exposure dose limit as 100 mSv for emergency operations such as lifesaving (alarm is set at ranges from 30 to 50 mSv), and 100 mSv over five years for those who repeatedly engage in the operations (it should not exceed 50 mSv in any given year).

Fire fighting team members working within 20 km of Fukushima Dai-ichi NPS have their exposure doses measured after the operations, and as of May 31, there is no member whose

exposure exceeds the limit.

2. Response to radiation exposure of residents in the vicinity and the overall situation

(1) Distribution of stable iodine, etc.

1) Situation of acquiring stable iodine

Fukushima Prefecture distributed necessary iodine (pills: about 1.51 million pills (for about 0.75 million people), powder: about 6,100 g (for about 0.12 to 0.18 million people)) to cities, towns and villages with administrative districts within 50 km of the Fukushima Dai-ichi NPS.

This amount exceeds the need for 0.69 million people, or the population equivalent (of those under 40 years old) to the cities, towns and villages within the 50 km radius of Fukushima Dai-ichi NPS.

2) Policy for distribution to evacuated residents and their administration of stable iodine

The Director-General of Nuclear Emergency Response Headquarters will, on receiving advice from the Nuclear Safety Commission of Japan (NSC Japan), give instructions to the related cities, towns and villages on the dose of stable iodine for evacuated residents, although the designated cities, towns and villages will distribute stable iodine to residents in the presence of medical experts. This is due to concerns of side effects associated with administration, such as iodine allergies.

Stable iodine is stored in the offices of cities, towns and villages and it is necessary to decide on the procedure to precisely distribute the stable iodine to residents in the event of a real evacuation. In this case, because the preliminary distribution of stable iodine to residents is not appropriate, the cities, towns and villages are to adopt necessary measures so that they can securely distribute iodine to their residents according to various types of evacuation scenarios as described below. In addition, the local governments are requested to take note so that they will not unnecessarily cause anxiety among residents, while keeping them fully informed.

(Evacuation patterns)

i. Residents using evacuation buses:
Distributed and administrated at the evacuation site or in the buses

ii. Hospitalized and bed-ridden residents:
Distributed and administered in a hospital, etc. or a bus

iii. Residents evacuating on their own:
Distributed and administered at a doctor's discretion (age and evacuation time, etc. are considered) in an evacuation site or at a screening point

3) Situation of responses regarding directions on the administration of stable iodine

On March 12, instructions were given by the Director-General of the Nuclear Emergency Response Local Headquarters to the Governor of Fukushima Prefecture and 43 surrounding towns to evacuate residents from within 20 km. In the process of evacuation, the possibility of radiation dose increase among the people being evacuated became undeniable due to the hydrogen explosion at Unit 3 (March 14), etc. For this reason, on March 16, the Director-General of the Nuclear Emergency Response Local Headquarters instructed the Governor of Fukushima Prefecture and others to have residents take stable iodine when evacuating from within the 20 km radius of the nuclear power plant, taking into account the technical advice from NSC Japan recommending that stable iodine be administered to residents remaining in the area (within 20 km) upon evacuation. Although the completion of evacuation was acknowledged, this instruction was given as a cautionary measure assuming there might be cases in which residents who couldn't evacuate were left behind. But as a matter of fact no residents took stable iodine based on this instruction because the evacuation had already been completed at the time the instruction was issued. Also, on March 21, the Director-General instructed the Governor on precautions necessary in administering stable iodine.

(2) Standards and methods of screening and decontamination

On March 13, Fukushima Prefecture determined the screening level in the case of decontaminating the whole body at 100,000 cpm and that partial decontamination by wiping would be performed in case of detection of numerical values greater than 13,000 cpm but less than 100,000 cpm, based on the opinions of experts in radiation medicine dispatched from MEXT, and doctors and others from the National Institute of Radiological Sciences, and guidelines of Fukushima Medical University.

Meanwhile, on March 19, NSC Japan determined the screening level for decontamination at 100,000 cpm. The revised screening level of 1 μSv/h (dose rate at a distance of 10 cm) is a standard of decontamination for contamination on the surface of the body for general residents as stipulated by the International Atomic Energy Agency (IAEA) in the *Manual for First Responders to a Radiological Emergency* (VII 2-1).

Note: Measured values are those measured using Type TGS-136 GM Survey Meter (5cm bore).

(3) Status of radiation exposure for residents in the vicinity

With regard to the contamination of residents, Fukushima Prefecture has been implementing screening surveys for residents in the prefecture including people evacuated from within the 20 km radius of the power plant in cooperation with the Nuclear Emergency Response Local Headquarters. Most of the 195,354 people checked as of May 31 were under the 100,000 cpm limit. Decontamination was performed for 102 people exceeding 100,000 cpm but their contamination levels fell to levels of no concern after such decontamination.

In addition, from March 26 through March 30 the Nuclear Emergency Response Local Headquarters implemented a survey on thyroid exposure for infants in Iwaki City, Kawamata Town and Iidate Village in cooperation with Fukushima Prefecture in order to understand more precisely the current exposure dose, particularly the health effects to infants who are highly-sensitive. In its implementation, exposure of infants was measured in areas where residents were instructed to stay in-house, or in areas whose equivalent dose in thyroid glands was rated as high by the estimation derived by SPEEDI (announced on March 23). Technical advice was received from NSC Japan for the method. From the results among the 1,080 children from 0 to 15 years old that were surveyed for thyroid exposure, there were no children who exceeded the screening level of 0.2 μSv/h (an equivalent to a thyroid gland equivalent dose of 100 mSv for a one-year-old baby)

3. Evaluation of the status of radiation exposure

The purpose of radiation protection is to prevent the occurrence of a deterministic effect on an individual, and unfailingly take all reasonable measures to limit the occurrence of stochastic effects.

(1) Evaluation of the status of radiation exposure by operators

Operators are responsible for the appropriate performance of radiation control measures for radiation workers based on a predetermined plan. In this accident, tsunamis rendered APDs unusable and the functionality of radiation control measures was lost. Moreover, the radiation and contamination levels not only within the nuclear power station facilities but also on the site increased as the accident progressed.

Performing precise control of dosages is the basis of performing appropriate radiation control measures for radiation workers. However, because of the insufficient number of dosimeters for the above reasons, actions such as equipping only work unit leaders in relatively low environmental doses were taken. TEPCO should have acted promptly to make it possible to equip every person with a dosimeter.

Moreover, since evaluations of individual doses rely upon manual recording due to a loss of the functionality of the system, and evaluations are based on behavior record because measuring the doses of each individual by an APD was impossible, it took considerable time to establish a system for radiation control measures equivalent to the system which was in place before the tsunamis.

Moreover, the delay in management to prevent radioactive materials from entering the quake-proof buildings and that of measuring the concentration of radioactive materials in the air within the building resulted in increasing the risk of internal exposure.

At Fukushima Dai-ichi NPS, whole body counters (WBC) became unusable due to the increase of the background level. Therefore, vehicle-mounted WBC were borrowed and have been used for measurement while WBC measurement is being performed at another power station, where internal exposure is being evaluated. However, there are too many people to be measured. Thus, WBC measurement is performed at different power stations and internal exposure is assessed, however, a sufficient measurement system has not been established.

For this reason, TEPCO performed WBC measurement and evaluated dose rates preferentially to workers with high external exposure doses and to those who were engaged in emergency operations in March. However, at present, two workers were confirmed to have high internal radiation doses (iodine 131) in their thyroid glands in the evaluation of internal exposure doses. Currently, dose evaluation has been performed on those two workers and there is a possibility

that their dose limit may exceed 250 mSv, the dose limit for working in emergency operations. Furthermore, there is a possibility that some workers engaged in emergency operations right after the accident in March may be evaluated as having doses close to the limit or doses that may exceed the limit in line with the progress of internal exposure dose evaluation. TEPCO is planning to evaluate the internal exposure of the workers engaged in emergency operations in March immediately.

Meanwhile, after July, TEPCO will transfer the WBC at Fukushima Dai-ichi NPS and Fukushima Dai-ni NPS to J Village, and plans to coordinate a measurement system at J Village by purchasing a new WBC and taking other suitable steps.

At Fukushima Dai-ichi NPS, along with the increase of the radiation dose, the non-controlled area was required to be controlled as a controlled area. Against this backdrop, workers who were not designated as radiation workers worked in places where it should have been controlled as the same level as the controlled area, and resulted in the exposure exceeding one mSv per year, the yearly dose limit for the public. This is because the initial individual dose control was not appropriate in line with the enlargement of target area for radiation control measures.

(2) Evaluation of the situation of radiation exposure of residents in the vicinity

Regarding the evaluation of radiation doses received by residents, Fukushima Prefecture will hereafter conduct surveys in target areas in cooperation with related government offices and the independent administrative institutions, NIRS and others, and will estimate and evaluate the radiation dose received by each resident by comparing it to the results of the situation for the release of radioactive materials separately surveyed, etc.

There are estimated to be about 2 million residents of Fukushima Prefecture to be surveyed and the survey would be conducted as part of the health management survey of Fukushima Prefecture. Since the evacuated people have been dispersed by the earthquake and accident, the survey plans to start with people who have a high viability to receive a survey such as current residents, and in principle, evacuated people whose residence after their evacuation is easily tracked

(3) Evaluation of emergency medical system for exposures

As a precaution, there were some cases, in which some people engaged in emergency work for this accident at Fukushima Dai-ichi NPS, etc. were transported to an independent administrative institution, NIRS, which is a tertiary emergency medical institution for exposure, but there were no cases serious enough to be treated as tertiary exposure.

As this nuclear disaster caused by the Great East Japan Earthquake, was a disaster beyond the assumptions of conventional nuclear disaster countermeasures that required responses to earthquakes and tsunamis at the same time, the local governments first strengthened their systems by coordinating with medical institutions such as university hospitals nationwide on such issues as how to cope with the high numbers of injured or sick patients.

As such, Fukushima Medical University, an institution for secondary exposure, and other medical institutions in the prefecture, were obliged to work under complex emergency conditions such as simultaneously performing disaster medical measures including dispatching on-site disaster medical care. Therefore there is a possibility that these institutions could not sufficiently respond when emergency response against radiological exposure was really needed compared to the anticipated response in the field by the regional disaster prevention plans, which were planned in advance.

However, as the Nuclear Emergency Response Local Headquarters led the immediate restructuring of the medical system for exposure and strengthened the response system in cooperation with related institutions such as university hospitals including tertiary medical institutions for exposure, the medical system for exposure is considered to be performing its necessary functions.