Results of the Additional Re-evaluation of Committed Effective Doses of Emergency Workers at TEPCO's Fukushima Daiichi Nuclear Power Plant

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Labour Standards Bureau
Ministry of Health, Labour and Welfare

The Ministry of Health, Labour and Welfare (MHLW) instructed TEPCO and primary contractors to conduct re-evaluation as follows, and readjusted the committed effective doses of emergency workers based on the results of the re-evaluation.

1. Method of the additional re-evaluation

(1) Detailed procedures for calculating committed effective doses for each of the standard assessment methods ((i) to (vi) shown in Attachment 1) were required for conducting exposure assessment in epidemiological studies concerning the effects of radiation on the thyroid gland, targeting emergency workers at Fukushima Daiichi NPP (special studies covered by the Health and Labour Sciences Research Grants).

(2) TEPCO divided its data for assessing workers' committed effective doses into assessment methods, with the aim of providing them to cooperate with the studies. In that process, on 31 January, 2014, it was found out that committed effective doses for nine workers had been assessed by a method other than the standard assessment methods.

(3) In order to check whether there were any similar cases, from 4 February, 2014, the MHLW closely examined committed effective dose data for workers engaged in March and April 2011, which were assessed by TEPCO and contractors. The ministry input all the data (for 6,245 workers (1,845 at TEPCO and 4,400 at contractors) excluding 1,284 workers[1] covered by the previous re-evaluation) into a data sheet as shown in (i) to (vi) of Attachment 1 and, as a result of the examination, it became clear that committed effective doses for a total of 1,536 workers (608 at TEPCO and 928 at contractors) may have been assessed by a method other than the standard assessment methods (see Attachment 2 for details).

(4) The MHLW collected recommendations from experts concerning issues newly identified (Attachment 3) and instructed TEPCO and primary contractors to re-evaluate their data on workers' committed effective doses and readjust them as necessary, based on Attachments 2 to 4, on 6 March, 2014.

(5) As a result of re-evaluation based on Attachments 2 to 4, it was found that the data need to be readjusted for a total of 142 workers (24 at TEPCO and 118 at 18 contractors) whose committed effective doses exceed 2mSv (on recording level) with a fluctuation range of +1mSv or larger.

2. Principles of the additional re-evaluation and difference from the previous re-evaluation

(1) Principles

a. Article 8, paragraph (5) of the Ordinance on Prevention of Ionizing Radiation Hazards provides that committed effective doses shall be calculated by methods specified by the

[1] Including 25 workers who were later found to have not entered TEPCO's Fukushima Daiichi NPP

Minister of Health, Labour and Welfare. However, the Ministerial Notice for specifying the methods only indicates the principle for the measurement of committed effective doses and does not define any detailed methods.

b. There are multiple methods to assess committed effective doses depending on circumstances regarding exposure. Under circumstances with uncertainty, lacking very basic information, i.e., when workers took in radioactive substances, TEPCO and contractors adopted methods that they considered optimal at their option. This is not an issue of which method was correct or incorrect.

c. Under circumstances with uncertainty, the MHLW provided administrative guidance to choose assessment methods so as to ensure conservative assessment within a reasonable extent and to standardize assessment methods of committed effective doses to the extent possible.

(2) Difference between the previous reevaluation in July 2013 and the current additional re-evaluation

a. Under the assumption that each entity has the discretion to decide their methods to assess workers' committed effective doses, the re-evaluation conducted in July 2013 selected the data in which assessment results by contractors were lower than those by TEPCO and whose validity was doubted and tried to confirm the validity of such discrepancies in the data. Therefore, the previous re-evaluation only covered the data selected as those with discrepancies and the data voluntarily readjusted by contractors and TEPCO, out of all the results of the assessment conducted by contractors.

b. The current additional re-evaluation was conducted with the aim of completely integrating detailed measurement results by nuclide, various coefficients, calculation procedures, etc., which will be necessary for exposure assessment in epidemiological studies. This is administrative guidance to get involved in the details of assessment methods, whose choice is left to the discretion of employers, and covers all the data on committed effective doses of emergency workers, apart from the previous re-evaluation

3. Results of the additional re-evaluation

(1) Outline

a. Subjects for close examination (emergency workers with internal exposure in March and April 2011; excluding 1,284 workers covered by the previous re-evaluation): 6,245 workers (1,845 at TEPCO and 4,400 at contractors) (See Attachments 2 and 3 for details.)

b. Subjects for re-evaluation: 1,536 workers (608 at TEPCO and 928 at contractors)

c. Subjects for readjustment (limited to those whose committed effective doses were not less than 2mSv with a fluctuation range of + 1mSv or larger): 142 workers (24 at TEPCO and 118 at 18 contractors)

(i) Fluctuation range: 5.86mSv on average (1.01mSv to 89.83mSv)

(ii) Effective dose (emergency exposure dose): 2.17mSv to 180.10mSv

(2) The number of workers whose committed effective dose exceeded 100mSv increased by one. (See Addition 4 in Attachment 3 for details.)

a. Fluctuation range: 89.83mSv (internal exposure: 100.05mSv; external exposure: -10.22mSv)

b. Effective dose: 90.27mSv → 180.10mSv (internal exposure: 37.11mSv → 137.16mSv)

c. Grounds for the readjustment:

(i) Measurement values with WBC (Ge), which has high measurement accuracy, have also shown high levels of Cs-137. Considering the fact that the ratio of I-131/Cs-137 in the environment was around 100, even taking into account the residual ratio by the measurement date, the residual amount of I-131 in the body on the measurement date must have been around 10 times higher than that of the minimum detectable amount (MDA). However, I-131 was inexplicably not measured. Therefore, TEPCO considered that stable iodine tablets taken by the workers had been effective to some extent and did not conduct an estimation of exposure to I-131 by any of the standard methods.

(ii) However, based on the recommendations from experts, the MHLW considered it preferable to ignore the effects of the stable iodine tablets, as long as the possibility of exposure to I-131 cannot be completely denied, even though this may result in overassessment. Consequently, the ministry instructed TEPCO to estimate exposure to I-131 under the assumption that the MDA of I-131 was detected and to add such estimated values to the data.

(3) The number of workers whose emergency exposure dose exceeded 50mSv but did not exceed 100mSv increased by two. (See Addition 2 in Attachment 3 for details.)

a. Fluctuation range: 2.44mSv; 3.67mSv
b. Effective dose: 49.4mSv → 51.84mSv; 46.9mSv → 50.57mSv
c. Reasons for the readjustment: Estimation of exposure to I-131 was not conducted because Cs-134 was detected but Cs-137 was not detected (Case B-2 in Attachment 2).

4. Responses by the MHLW

(1) The MHLW provides TEPCO with guidance on the following matters.

a. The internal audit sector should inspect the sector in charge of the management of personal doses, check the flow of its operations and data management, etc., and take necessary remedial actions.
b. Before externally reporting or announcing radiation exposure doses, the data should be checked by a person in charge of radiation management in a quality management sector, in principle.

The ministry also instructs contractors (that independently assess committed effective doses) about thorough preservation of all records, etc.

(2) Based on the Minister's guidelines, the MHLW demands employers to provide their workers with cancer screening tests, etc., in addition to mandatory medical examinations, in accordance with the readjusted committed effective doses. After the retirement, the national government will provide workers with these medical examinations. (See Supplemental Data.)

(3) Rigorous epidemiological studies, including surveys of the age structure, personal habits of smoking and drinking and medical histories, etc., are indispensable for identifying health effects of radiation. Therefore, the ministry will steadily carry out required epidemiological studies.

a. FY2013: Studies on cataracts and studies on thyroid glands
b. FY2014 onward: Steadily carry out required studies in addition to the studies conducted in FY2013

Methodologies of Internal Exposure Dose Assessments (Standard Methods)

Cases	Details of the methods used	Results of the re-evaluation
(i) Where I-131 was detected with WBC (Ge)	TEPCO sent its female workers and workers whose assessed internal dose exceeded 20mSv to the Tokai Research and Development Center Nuclear Fuel Cycle Engineering Laboratories of the Japan Atomic Energy Agency (JAEA) for precise measurement. The JAEA carried out measurement of internal doses, using a whole-body counter (Ge semiconductor detector) (WBC (Ge)). With regard to seven workers whose internal doses were likely to exceed 250mSv, measurement was carried out at the National Institute of Radiological Sciences (NIRS), using WBC (Ge). Based on the measurement results obtained from the JAEA and the NIRS, TEPCO assessed the relevant workers' committed effective doses of I-131.	Total: 126 (114 at TEPCO; 12 at contractors) Re-evaluated: 48 (47 at TEPCO; one at a contractor) Readjusted data: 3 (2 at TEPCO; one at a contractor) Range: 8.45mSv on average (4.32mSv to 12.91mSv) Readjusted doses: 35.01mSv to 91.99mSv
(ii) Where I-131 was detected with a NaI survey meter	As there were not enough WBCs available, TEPCO and contractors used NaI survey meters, which are originally supposed to be used for measuring ambient dose rates. They put the detecting probe of a NaI survey meter directly against the neck of a worker to measure the gamma ray from the thyroid gland. They multiplied the readings by the thyroid gland deposition coefficient and thereby evaluated I-131 intake by the thyroid gland.	Total: 178 (5 at TEPCO; 173 at contractors) Re-evaluated: 79 (2 at TEPCO; 77 at contractors) Readjusted data: 0 (0 at TEPCO; 0 at contractors)
(iii) Where I-131 was detected with WBC (NaI)	TEPCO borrowed vehicle-mounted whole-body counters (NaI scintillation detector) (WBC (NaI)) from the JAEA and carried out measurement of internal doses at the Onahama Call Center (approximately 50km from the NPP) and in Tokyo. Based on the measurement results, TEPCO assessed internal doses of the relevant workers.	Total: 491 (238 at TEPCO; 253 at contractors) Re-evaluated: 69 (52 at TEPCO; 17 at contractors) Readjusted data: 2 (0 at TEPCO; 2 at contractors) Range: 1.87mSv on average (1.01mSv to 2.74mSv) Readjusted doses: 13.15mSv to 26.18mSv
(iv) Where I-131 was not detected with WBC (NaI)	As most of the measurement using WBC (NaI) was carried out in June 2011 or later, when more than two months had elapsed since the accident, I-131, with its short half-life, was not detected in many cases. In such cases, TEPCO adopted the lower values of I-131 estimated by either of the following standard methods, as the relevant workers' committed effective doses of I-131. a) Estimation based on the minimum detectable amount (MDA): Under the assumption that the MDA of I-131 was detected, I-131 intake was estimated based on the residual scenario. b) Estimation using the ratio of I-131/Cs-137 in the environment: I-131 intake was estimated by multiplying measured Cs-137 intake by the ratio of I-131/Cs-137 in the environment measured at TEPCO's Fukushima Daiichi NPP.	Total: 4,135 (1,284 at TEPCO; 2,851 at contractors) Re-evaluated: 701 (349 at TEPCO; 352 at contractors) Readjusted data: 76 (11 at TEPCO; 65 at contractors) Range: 4.38mSv on average (1.23mSv to 35.54mSv) Readjusted doses: 2.81mSv to 149.18mSv
(v) Where I-131 was not detected with WBC (PL)	As the WBC (plastic scintillation detector) (WBC (PL)) installed at TEPCO's Kashiwazaki-Kariha NPP cannot identify nuclides, calibration is conducted by using Cs-137 as a calibration source. Therefore, TEPCO formulated an approximation for calculating I-131/Cs-137 ratios for each measurement date by comparing significant values of I-131 measured with NaI survey meters as mentioned in (iii) and values of Cs-137 measured with WBC (PL). Committed doses of I-131 were estimated by multiplying measured values of Cs-137 by I-131/Cs-137 ratios.	Total: 1,263 (188 at TEPCO; 1,075 at contractors) Re-evaluated: 599 (148 at TEPCO; 451 at contractors) Readjusted data: 44 (6 at TEPCO; 38 at contractors) Range: 4.29mSv on average (1.27mSv to 22.81mSv) Readjusted doses: 2.17mSv to 73.41mSv
(vi) Where I-131 was not detected and I-131/Cs-137 ratios for workers engaged in the same work were	When I-131/Cs-137 ratios of coworkers engaged in the same work during the same period were available, committed effective doses of I-131 were estimated by multiplying measured values of Cs-137 by said ratios, instead of applying method (iv) or (v). When there were any internal dose assessment results by other nuclear facilities, such data were adopted.	Total: 52 (16 at TEPCO; 36 at contractors) Re-evaluated: 40 (10 at TEPCO; 30 at contractors) Readjusted data: 17 (5 at TEPCO; 12 at contractors) Range: 16.54mSv on average (2.28mSv to 89.83mSv) Readjusted doses: 3.58mSv to 180.10mSv

used, etc.		
Total	Targets for close examination: 6,245 (1,845 at TEPCO; 4,400 at contractors) Targets for re-evaluation: 1,536 (608 at TEPCO; 928 at contractors) Readjusted data: 142 (24 at TEPCO; 118 at contractors) Range: 5.86mSv on average (1.01mSv to 89.83mSv) Readjusted doses: 2.17mSv to 180.10mSv	

Attachment 2

[Cases Subject to Additional Re-evaluation]

Case	Determinations by MHLW	Remarks
● Case A-1 (Date of commencing work/Intake date) Where external exposure doses were recorded for the period between 11 March and the end of April 2011, but the date of commencing work and the intake date do not match ● Case A-2 (Date of commencing work/Intake date) Where external exposure doses were recorded for the period between 11 March and the end of April 2011, but the date of commencing work (intake date) is later than the date of recording external exposure doses. ● Case B-1 (No iodine estimation) Where I-131 was not detected, and estimation of I-131 was not conducted although Cs-137 was detected ● Case B-2 (No iodine estimation) Where I-131 was not detected but Cs-134 was detected, and estimation of I-131 was not conducted because Cs-137 was not detected ● Case C-1 (Failure to obtain measurement data, etc.) Where all measurement results by other nuclear operators were adopted and measurement results using WBC and other data were not reported to TEPCO ● Case C-2 (Failure to obtain details of assessment methodologies) Where TEPCO insists that assessment is conducted based on data on internal exposure doses measured for the same worker or by other methods, but the details of assessment methodologies are not reported to TEPCO ● Case D Any case other than Cases A to C, where there are discrepancies exceeding 0.1mSv (including positive and negative discrepancies) between values calculated by any of the standard methods based on data held by TEPCO and values submitted by contractors	● Case A-1 Check the results of the behavior research, record of receiving WBC tests, record of external exposure doses, shift roster, and the results of worker examinations, etc. (hereinafter referred to as the "behavior research") to reconfirm the date of commencing work (intake date). Adopt the most reliable date, and conduct assessment again based on Item 1 of Attachment 4. ● Case A-2 As there is a possibility that a relevant worker was engaged in work outside the facility site, reconfirm the results of the individual behavior research to check whether the worker entered Fukushima Daiichi NPP during the period between 11 March and the end of April 2011. If it is found that the worker entered the facility, conduct assessment again based on the adopted date of commencing work (intake date). ● Case B-1 Follow the standard method adopted by TEPCO. When using WBC (PL), conduct estimation in line with item 4 for the previous re-evaluation. When using WBC (NaI), reassess internal exposure to I-131 (when using the MDA, values should be divided by the estimation coefficient (2.935)), while taking into consideration Additional item 2. ● Case B-2 Under the assumption that the MDA of Cs-137 was detected or that the same amount of Cs-134 and Cs-137 was ingested, reassess internal exposure to I-131 in the same manner as in Case B-1 (see Additional item 2 of Attachment 3 for details). ● Case C-1 Obtain measurement results from other nuclear operators to check whether they are in conformity with TEPCO's standard methods. If they are not, conduct reassessment by the standard methods. ● Case C-2 Submit grounds for the assessment, such as the assessment results for the same worker, and attach explanations on the methodologies. ● Case D Investigate causes of the discrepancies by checking the results of the measurement using WBC and calculation processes, etc. If causes are unknown, reassess committed effective doses based on the standard methods.	Recorded doses were readjusted for data wherein committed effective doses were revealed to exceed 2mSv (on recording level) as a result of the re-evaluation, and readjusted values would increase by a range exceeding 1mSv.

[New Items for the Additional Re-evaluation]

Items	Standard assessment method by TEPCO	Approach of TEPCO for the additional re-evaluation	Determinations by MHLW
Additional item 1 Estimation coefficients for WBC (NaI) and WBC (Ge)	Attachment 1-2 Estimation methods for the cases where I-131 was not detectable due to the delay of measurement 1.Where the intake date is between March and June: In the cases where the intake date is between March and June and I-131 was not detectable, the intake radioactivity of I-131 is calculated by implementing the following estimation to assess the effective dose. (1) Estimation using the I-131/Cs-137 ratio based on the environmental data In the cases where I-131 was not detectable and Cs-137 was detected, the following estimation is applied. ・Intake radioactivity of Cs-137 is calculated by dividing the measured value of Cs-137 by the residual ratio (①→②) ・Intake radioactivity of I-131 is calculated by multiplying the intake radioactivity of Cs-137 by the ratio of I-131/Cs-137* in the environment on the intake date (②→③) (2) Estimation using the MDA of I-131 ・Intake radioactivity of I-131 is calculated by dividing the MDA of I-131 by the residual ratio of I-131 (④→⑤) (3) Decision of the estimated value ・The lower value between the estimated value based on the environmental data and the one based on the MDA is adopted as the intake radioactivity of I-131. (4) Evaluation based on the data on the intake radioactivity, etc. of other workers who were engaged in the work in the same period ・Intake radioactivity of I-131 may also be assessed from the data on intake radioactivity, etc. of other workers who were engaged in the work in the same period. *Ratio of I-131/Cs-137	・As both Cs-137 and I-131 were not detectable at the first WBC measurement (13–21 May), the intake radioactivity of I-131 was assumed to be the value of MDA of WBC (NaI). ・The latest findings revealed that the ratio between the I-131 value assessed based on the results of the WBC (Ge) measurement at Onahama and the one based on the results of the WBC (Ge) measurement for the monitoring of thyroid glands at the Tokai Research and Development Center (TRDC), JAEA, is a factor of 2.935. In order to reflect this finding, the residual radioactivity should be calculated by dividing the MDA by 2.935 when estimating the intake radioactivity of I-131 by MONDAL.	① According to the reference,[2] the results of the assessment on 24 examinees showed that the value of I-131 evaluated by a WBC (NaI) is three times as high as that evaluated by a WBC (Ge) when the intake radioactivity was estimated with the MDA. ② The WBC (NaI) used by TEPCO in Onahama and the WBC (NaI) installed at TRDC of JAEA were of the same type (Canberra's Fastscan system) but differed in terms of models, which is believed to be the reason for the gap between the values in the reference and TEPCO's data. ③ In either case, it is obvious that WBC (NaI) systematically overestimates the value in comparison with WBC (Ge). Thus, it is adequate to estimate the intake radioactivity of I-131 using the MDA divided by 2.935. ④ In this case, the radioactivity of I-131 measured by WBC (NaI) (or MDA) divided by 2.935 is deemed as the radioactivity of I-131 that remained in the thyroid gland. Therefore, the residual ratio for the thyroid gland should be used for the calculation rather than that for the whole body, even though the subject of the measurement by WBC (NaI) was the whole body.

[2] O. Kurihara, K. Kanai, T. Nakagawa, C. Takada, T. Momose, S. Furuta, Direct measurements of employees involved in the Fukushima Daiichi nuclear power station accident for internal dose estimates: JAEA's experiences. NIRS-M-252, 13-25, 2012.

	The ratio of I-131/Cs-137 is set based on the environmental data measured on the intake date.		

Items	Approach of TEPCO for the additional re-evaluation	Determinations by MHLW
Additional item 2 Estimation methods for the cases where I-131 was not detectable by WBC (NaI) (where Cs-137 was not detectable but Cs-134 was detected)	As a result of considering the workers from whom Cs-137 and I-131 were not detectable but Cs-134 was detected, approaches for such workers are set as below. 1 The detected Cs-134 values lower than the maximum value (618Bq) of the MDA of Cs-134 among 76 workers should be disregarded. The value of Cs-134 should be deemed as lower than the MDA. 2-1 In the cases other than the case described in 1, the intake radioactivity of Cs-137 should be estimated assuming the MDA of Cs-137 of individual workers as a residual radioactivity. 2-2 When the MDA of Cs-137 is unknown, the intake radioactivity of Cs-137 should be estimated assuming that the same radioactivity as that of Cs-134 was taken in. 3 The intake radioactivity of I-131 should be determined using the ratio of I-131/Cs-137 based on the intake radioactivity of Cs-137 estimated in 2. 4 The lower value between the intake radioactivity of I-131 estimated in 3 and the one estimated assuming the MDA of I-131 as the detected value is adopted (same as the standard methods).	The cases where only Cs-134 is detected is considered to be attributed to the analytical random error due to the statistical fluctuations of the measured values of each channel of the spectrum, since such cases tend to increase when the radioactivity of Cs-134 inside the body is lower. Therefore, it is adequate to estimate the intake radioactivity of Cs-137 on the assumption that the MDA of Cs-137 has been detected. (Approach of TEPCO 2-1) On the other hand, it is an adequate alternative method to substitute the value of Cs-137 by the detected radioactivity of Cs-134 in the whole body as Cs-134 and Cs-137 existed in similar proportions in the initial phase of the accident (Approach of TEPCO 2-2) However, there is a risk of underestimating the radiation exposure dose of Cs-134 if a concept of threshold (618Bq in this case) is introduced to deem any lower values of detected internal Cs-134 dose as undetectable (although the value of the dose to be underestimated should be very small). Therefore, MHLW determines that the screening based on Approach of TEPCO 1 should not be adopted.

Items	Standard assessment method by TEPCO	Approach of TEPCO for the additional re-evaluation	Determinations by MHLW
Additional item 3 Addition of stand-by exposure doses	The additional exposure doses during stand-by (stand-by exposure dose) of employees of TEPCO are evaluated as follows. 1 Stand-by exposure doses in March The stand-by exposure doses were estimated based on the data measured with the passive dosimeters of the primary contractors (measured between 15 March and 31 March) and values measured with the survey meter at the emergency countermeasure office in the seismically isolated building (measured between 12 March to 14 March). Based on this estimation, the dose was defined as 8.56mSv in the cases where the employee stayed at the seismically isolated building from 11 March to 31 March. 2 Stand-by exposure doses in April The stand-by exposure doses were evaluated based on the average of the values measured with glass badges installed in three locations of the emergency countermeasure office in the seismically isolated building (measured between 4 April and 30 April) and values measured with the survey meter at the same office (measured between 1 April and 3 April). Based on this estimation, the dose was defined as 2.06mSv for the cases where the employee stayed at the seismically isolated building from 1 April to 30 April. 3 Addition of stand-by exposure doses The dose of 8.56mSv is added as the dose to which the employees were exposed while they stayed at the seismically isolated building during the emergency work in March, regardless of the period of such stay. The dose of 2.06mSv is added as the dose to which the employees were exposed while they stayed at the seismically isolated building during the emergency work in April, regardless of the period of such stay. If the dose of each day of the stay was measured and evaluated separately, such dose may also be adopted as the stand-by exposure dose.	In accordance with the additional re-evaluation of radiation exposure doses, the doses of specified employees are individually re-evaluated by identifying the period of the stay at the seismically isolated building based on the attendance book, etc.	It is adequate to evaluate the stand-by exposure doses according to the attendance of individual employees.

Items	Approach of TEPCO for the additional re-evaluation	Determinations by MHLW
Additional item 4 Stable iodine tablets	・Values measured with WBC (Ge) at JAEA are less affected by surface contamination. Its measurement is most accurate and reliable. ・However, the values of I-131/Cs-137 in the environment as measured at the monitoring posts were approximately 290 times as high as the WBC (Ge) values above. The estimation based on the released amounts also show values approximately 70 times as high. Based on this premise, the amount of I-131 must have been ten times as much as the MDA at the time of the measurement even when taking into account the attenuation of I-131, which does not explain why I-131 was not detected from the workers. Therefore, it is reasonable to conclude that the stable iodine tablets administered to the workers had an effect to some extent. ・For the above reasons, it is not reasonable to estimate doses of I-131 by the standard methods. ・Thus, it is supposed to be adequate to use the ratio of I-131/Cs-137 of other workers from whom I-131 was detected after dosing stable iodine tablets ・Furthermore, it is also suggested that it is adequate to measure I-131 based on the measured value of Cs-137 of the workers who were involved in the explosion.	・As for the assessment of internal Cs dose, it is adequate to use the results of the measurement with WBC (Ge) at JAEA. ・As for the evaluation of dose of I-131, MHLW determined that, at this moment, it is adequate to estimate the dose of I-131 on the assumption that the value of MDA of WBC (NaI) divided by the estimation coefficient (see Additional item 1) was detected. The reasons are as follows: ① In principle, the measurements for the examinee him/herself should be used for the dose assessment. ② I-131/Cs-137 ratios of similar workers cannot be easily applied as the number of the data is not sufficient and such values are diverse. ③ It is not supposed to be adequate to use the I-131/Cs-137 ratio obtained from a recipient of stable iodine tablets (one worker) as the precise date of the dosage of stable iodine tablets is not clear. ④ The method is based on the standard scheme of dose assessment.

Attachment 4

[Details of the Re-evaluation in July 2013 (Excerpt)]

Items	Assessment method by TEPCO	Assessment methods by primary contractors	Determinations by MHLW	Revisions of doses
1 Intake date	・Cases when the work was started in March or April 2011: The day on which the work was commenced should be defined as the intake date. Note that the intake date should be set to 12 March if the work was commenced before 11 March 2011. (Concentrations of airborne radioactive materials tend to have gradually decreased, following drastic rise and fall after the hydrogen explosions. Thus, as workers who entered in March and April presumably received larger doses in the drastic rise and fall state of the concentrations of airborne radioactive materials, <u>their work commencement date should be set as the intake date.</u> <u>Note that the intake date can be dated back up to 12 March because the first hydrogen explosion occurred on that date.)</u> ・Cases when the work was commenced after May 2011: The intake date should be set in the middle of the work commencing and ending dates. (Because the concentration of the airborne radioactive material - iodine, the primary nuclide causing internal exposure - had decreased significantly after May,	[Plant manufacturers] The first day of the emergency work at the Fukushima Daiichi Nuclear Power Plant should be set as the intake date for the first measurement. For the later measurements, the first working day after the previous measurement should be set as the intake date. [TEPCO] The intake date was set as a middle day of the work period for backup workers (most of their work period was three days). [Nuclear facility employers, etc.] ・Doses of workers who had worked since 11 March 2011 (stayed in the seismically isolated building) were evaluated using the WBC (PL) and NaI survey meter of the Kashiwazaki-Kariwa Nuclear Power Plant, specifying 12 March as the intake date. ・For other workers except those above, doses were evaluated with WBC (NaI). The intake date was set in the middle of the work started date and the WBC measurement date. [Nuclear facility employers, etc.] The intake date should be set in the middle of the work starting and ending dates.	・ICRP recommends that the adequate monitoring frequency should be defined to evaluate internal exposure under normal conditions, when the middle day between monitoring is specified as the intake date. Note, however, that in case of an accident, the accident date needs to be set as the intake date in principle. ・Data at the West Gate indicates that the concentration of I-131 was on a linear declining trend in a logarithmic graph during the period from 19 March to the end of April 2011. ・For workers whose doses exceeded 250 mSv in June 2011, their internal exposure was evaluated as episodic intake on 12 March partly because they did not wear masks properly. ・Methods should be standardized to the TEPCO's conservative assessment method if individual and specific radiation exposure situation is unknown. ・Any results of behavior research of individual workers may be taken into consideration.	
		[Plant manufacturers] ・Workers working during the period from the date of the Great East Japan earthquake to 23 March 2011: According to the monitoring results of radioactivity concentrations in the environment, the date on which a significant amount of radioactive materials were released was set as the intake date.	・The method for determining the intake date for the period up to 23 March is appropriate to some extent. However, the TEPCO's method is more appropriate because the intake trend does not necessarily follow that of ambient dose rate outdoors.	

	the intake date is defined as the middle day of the working period.)	The date of the earthquake - 15 March -> 15 March 16 March - 18 March -> 18 March 19 March - 24 March -> 24 March		

Items	Assessment method by TEPCO	Evaluation methods by primary contractors	Determinations by MHLW	Revisions of doses
4 Assessment method using NaI survey meters in the case with WBC (PL) (to estimate I-131 measurements when they are not detected.)	Estimate internal exposure to I-131 for workers who entered the Fukushima Daiichi Nuclear Power Plant during the period from March to early May 2011, based on the past statistical data to assess it from the measurement results obtained after the elapse of a month or more from the intake date. ○ Assessment with addition of estimation based on statistical data (to assess effective dose from I-131): Calculate the effective dose from Cs-137 using the measurement results of WBC (PL) instead of using those of NaI survey meters, and determine the effective dose from I-131 by multiplying the value by the effective dose ratio (I-131/Cs-137) based on statistical data. The following formula should be used for the estimation. Y = -0.4633X + 18843 Y: effective dose ratio (I-131/Cs-137) X: intake date (a numerical value starting from 1 January 1900, which is defined as "1." Note that this assessment method is applied for the following cases: (I) Cases in which the dose rate obtained by the measurements of NaI survey meters apparently includes a low percentage of the dose rate originated from I-131 deposited on the thyroid. (Example) ・Case in which the impact of body surface contamination cannot be ignored ・Case in which the impact of the radioactivity of Cs-134 and 137 inside the body cannot be ignored ・Case of improper measurement timing, such as when the measurement date of a NaI survey meter elapsed a month or more from the intake date. (II) Cases in which the measurement was conducted only with WBC (PL), not with NaI survey meters (regular/off-line WBC inspections)	[Plant manufacturers][Nuclear facility employers, etc.] Assess internal exposure to iodine using the residual rate inside the body in "MONDAL 3" under the assumption that a measurement of the NaI survey meter is 0.01μSv/h when the meter indicated 0.00μSv/h.	・ Although it cannot be determined which method is more conservative, TEPCO's estimation formula seems more reasonable because it is based on the actual measurements. ・Either of these measures is acceptable but all contractors should adopt the same one.	
		[Plant manufacturers] Assess internal exposure to I-131 as zero when a measurement of the NaI survey meter is 0.00μSv/h.	Use the TEPCO's assessment method because internal exposure to I-131 may possibly be underestimated when the primary contractor's method is used.	
		[Nuclear facility employers, etc.][Plant manufacturers] ・Assess internal exposure to I-131 by obtaining a ratio of I-131/Cs-137 in the environment from the table when a measurement of the NaI survey meter is 0.00μSv/h. [Nuclear facility employers, etc.] ・ When applying a ratio of I-131/Cs-137, define half of a WBC (PL) measurement as that of Cs-137 and assess internal exposure to I-131 by multiplying the value by the ratio of I-131/Cs-137.	・ The trend of I/Cs ratio in the environment does not accord with that of I/Cs ratio actually ingested; the latter tends to indicate lower values. Presumably TEPCO's assessment method is more reliable because it is based on WBC (PL) measurements.	