**Re-evaluation results of committed doses for emergency workers at the TEPCO Fukushima Daiichi Nuclear Power Plant**

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Labour Standards Bureau

Ministry of Health, Labour and Welfare

Certain differences were identified in committed doses of emergency workers[1] at the TEPCO Fukushima Daiichi Nuclear Power Plant between finalized doses reported by primary contractors and provisional doses reported by the Tokyo Electric Power Company (TEPCO) at the end of April 2013. Therefore, the Ministry of Health, Labour and Welfare (MHLW) started reevaluation of these data in May 2013. Based on the reevaluation results, some of the committed doses were revised as shown below.

Part 1. Objectives and overview

1. Objectives and processes for reevaluation of internal exposure
   (1) Objectives and principles
      a. Compare the provisional and finalized values of committed doses of emergency workers which were evaluated respectively by TEPCO and primary contractors. For those with significant differences, investigate cause of the differences and, if required, revise the reported committed doses.
      b. Standardize the basis and methods for the evaluation among relevant parties so that evaluation can be made as conservative as reasonably possible (though there are significant uncertainties, such as ingestion dates).
   (2) Reevaluation process by MHLW
      a. The MHLW requested TEPCO to submit a report on data which had lower finalized values (difference was equal to 0.1 mSv or above) evaluated by primary contractors than provisional values (2 mSv or above, the level that required recording) evaluated by TEPCO, and obtained data on 431 workers.
      b. The MHLW interviewed with the five primary contractors who conducted the independent evaluation for the committed doses from internal exposure.

      Moreover, the primary contractors with the noticeable gap in data were called upon for

[1] For workers to whom the emergency radiation exposure dose limit (100 mSv; increased to 250 mSv for the period from 14 March 2011 to 16 December 2011) was applied. The application was ended, in principle, on16 December 2011.

investigation even in cases when they did not conduct their own independent evaluations.

2. Revision of committed doses
   (1) Based on the interview results and experts' opinions, the MHLW concluded that the data for a total of 138 workers would not require any revision.
   (2) Revising committed doses with the standardized evaluation method based on the reevaluation by the MHLW
      a. The interview results made the MHLW aware that the differences in some data occurred because primary contractors and TEPCO used different methods for evaluating internal exposure. Thus, the MHLW determined a standardized concept and evaluation methods in light of experts' opinions and instructed the relevant primary contractors to revise their committed doses using the standardized evaluation methods.
      b. This resulted in the revision of data for 293 workers.
   (3) Revising committed doses based on primary contractors' voluntary reevaluation
      a. In light of the concept stated in (2)-a., primary contractors voluntarily reevaluated some of their finalized values which were higher than the TEPCO's provisional values and which were not subject to the interview.
      b. As a result of the voluntary reevaluation, they submitted revised data for 186 workers.
   (4) Revision due to errors in calculations
      Errors in calculations were found during the reevaluation processes described in (2) and (3) above, and data for 29 workers were corrected and submitted.
   (5) Total
      As the total of (2) and (3) above, data for 479 workers were revised.

Part 2. Details of reevaluation results

1. Cases in which the differences of committed doses turned out appropriate (revision not required) (A total of 138 workers, see Attachment 1 for details.)
   (1) Cases in which the correct work commencement dates were available in primary contractors' records and used as the ingestion dates
      a. Some of the work commencement dates obtained by TEPCO were incorrect because they were collected verbally from the workers. Thus, we adopted written data from daily work reports, which would be more reliable, as the ingestion dates.
   (2) Cases in which data was evaluated using measurement data not owned by TEPCO

a. A NaI survey meter[2] was used to measure radiation exposure to Iodine 131 (hereafter referred to as "I-131") by putting it on throat area, and these measurements were used for the evaluation.

b. Data was measured by a whole body counter equipped with a plastic scintillation survey meter (hereafter referred to as "WBC (PL)"[3] at the TEPCO Kashiwazaki-Kariwa Nuclear Power Plant and the Fukushima Daini Nuclear Power Plant.

2. Revising committed doses by using the standardized methods for evaluating internal exposure

(1) Main points for revising the evaluation methods (See Attachment 2 for details.)

a. Common definition of the ingestion date (March 12 or the work commencement date should be used for the work until the end of April 2011).

b. Standardized ingestion scenario (as episodic ingestion instead of chronic ingestion for the work until the end of April 2011).

c. Standardized methods for estimating internal exposure to I-131 in case a WBC (PL) fails to detect it.

(2) Reevaluation results of committed doses with the revised evaluation methods

a. Revised committed doses for 497 workers (2.5% of 19,346 emergency workers)

(i) Revised committed dose evaluation results with the change of evaluation methods （A total 450 workers）

- Doses were corrected to higher values for 431 workers
  - ✧ +48.9 mSv to + 0.01 mSv, Average: +5.0mSv
- Doses were corrected to lower values for 19 workers (See Attachment 3 for details.)
  - ✧ -9.2 mSv to -0.3 mSv, Average: -2.1mSv

(ii) Corrected committed doses due to errors in calculations

- ✧ 29 workers from seven contractors: correction range: -3.5 mSv to ＋ 18.1 mSv

(3) Increase in the number of emergency workers with the effective doses exceeding 50 mSv or 100 mSv

a. An additional 12 workers exceeding 50mSv and equal to or less than 100 mSv during emergency work (by December 2011 in principle).

(i) 12 workers (from 2 contractors)

- Increased from 723 workers (as of December 2011) before the revision by 1.7%

[2] This survey meter is supposed to be used to measure ambient radiation exposure dose rate.
[3] A plastic scintillator type of whole body counter. Its resolution is too low to identify a nuclide.

- Variation range: 36.2 mSv to 3.2 mSv (committed dose), average 13.4 mSv
- Effective doses after the revision: 65.19 mSv to 51.4 mSv
- Major reasons for the revision: Revision of the ingestion date to the work commencement date (Figure 1), and revision of the ingestion scenario.

b. Committed doses of an additional 6 workers exceeded 100 mSv (See Attachment 4 for details.)

(i) A total of 6 workers (3 from TEPCO, 3 from contractors)

- Increased from 167 workers before the revision by 3.6%)
- Variation range: 48.91 mSv to 7.39 mSv (internal committed dose), average 21.3mSv
- Effective doses after the revision: 148.78 mSv to 101.83 mSv
- Major reasons for the revision: Revision of the ingestion date established on the mid-term day to the work commencement date.

(ii) 3 TEPCO employees[4]

- 99.87→148.78 mSv (committed dose 61.00 mSv→109.91 mSv)
- 92.83→102.69 mSv (committed dose 28.4 mSv→38.26 mSv)
- 94.44→101.83 mSv (committed dose 14.98 mSv→22.37 mSv)

(iii) 3 employees of contractors (2 contractors)

- 79.67 mSv→102.17 mSv (committed dose 33.6 mSv→56.1 mSv)
- 91.70 mSv→123.20 mSv (committed dose 47.2 mSv→78.7 mSv)
- 99.23 mSv→106.93 mSv (commited dose 10.1 mSv→17.8 mSv)

3. Correction due to errors in calculations (See Attachment 5 for details.)

(1) Description of errors in calculations

a. Errors when inputting factors (such as effective dose factor) used for iodine correction calculation: a total of 4 workers

b. Failure of TEPCO to send internal exposure measurement results to primary contractors: a total of 6 workers

c. Misidentification with other employee's data : a total of 1 worker

d. Failure to update the in-house records with the internal exposure measurements provided by TEPCO: a total of 17 workers.

e. Error in the measurement reported to TEPCO: a total of 1 worker

(2) Corrected results

[4] The dose of one of the TEPCO employees exceeded 100mSv while he or she was engaged in the work under the designated high dose rate (i.e., work that applies the emergency radiation exposure limit such as cooling down nuclear reactor).

a. A total of 29 workers from 7 contractors

b. Correction range: -3.5 mSvto18.1 mSv

(3) Actions by the MHLW

The MHLW will provide strict instructions by way of the competent Labour Standard Inspection Office to prevent the recurrence.

Cases in which the differences were proven as appropriate

| Observed differences | Reasons for the differences | Evaluation method by TEPCO | Evaluation method by primary contractors | Determination by MHLW |
|---|---|---|---|---|
| The MHLW confirmed that the differences in data for 138 workers were valid.<br><br>The differences from TEPCO's provisional values ranged from 87.7 mSv to 0.48 mSv.<br>(Average: 7.45 mSv) | Although the same WBC measurement results were used between TEPCO and a contractor, the elapsed days after the ingestion date were different because TEPCO was unaware of the work commencement dates and non-working dates. | Asked workers about their work commencement dates when conducting WBC measurement, and recorded them. | Checked the work commencement dates with daily work reports, daily work log books, and others. | Evaluation provided by primary contractors is more appropriate because the work started dates are more reliable, based on objective materials such as daily work reports. |
| | | TEPCO was unaware of non-working days during the work period. | As workers took off work for some days after the measurement, the number of non-working days was subtracted from the elapsed days until the next measurement evaluation. | It is appropriate to define the work re-starting date as the ingestion date for the next measurement if workers were away from the work after the previous measurement. |
| | TEPCO did not know about the fact that different measurement evaluation data for internal exposure were used among TEPCO and contractors | The significant values were not measured in the internal exposure to I-131 through WBC (PB) by TEPCO.<br>Thus, TEPCO estimated exposure to I-131 using the measurement results for Cs. | Among data obtained through WBC (PL) and NaI survey meters of the TEPCO Kashiwazaki-Kariwa Nuclear Power Plant and the Fukushima Daini Nuclear Power Plant, a simple method for measuring I-131 using NaI survey meters indicated some significant values.<br><br>Evaluated internal exposure based on the I-131 measurements. | Estimating I-131 with Cs measurements produced considerable errors. Therefore, the evaluation of exposure to I-131 based on the significant I-131 measurement results is more reliable. |
| | | Evaluated internal exposure to Cs and estimated internal exposure to I-131 using the Cs measurements obtained by TEPCO. | Among data measured with WBC (PL) and others of the TEPCO Kashiwazaki-Kariwa Nuclear Power Plant and the Fukushima Daini Nuclear Power Plant, there were some significant measurement results for Cs. Thus, the evaluation of internal exposure to Cs was calculated by dividing elapsed days into some portions. . | Smaller intervals between the ingestion date and the measurement date provide more precise evaluation. Thus, it is recommended that any multiple measurement results should be utilized to make the measurement intervals as short as possible. |

Differences in the methods for evaluating committed doses among TEPCO and primary contractors and their actions

| Items | Evaluation method by TEPCO | Evaluation methods by primary contractors | Determinations by MHLW | Revisions of doses |
|---|---|---|---|---|
| 1<br>Ingestion Date | ・Cases when the work was started in March or April 2011:<br>The day on which the work was started should be defined as the ingestion date.<br>Note that the ingestion date should be set to 12 March if the work was started before 11 March 2011.<br>(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, their work commencement date should be set as the ingestion date.<br>Note that the ingestion date can be dated back up to 12 March because the first hydrogen explosion occurred on that date.<br><br>・Cases when the work was started after May 2011:<br>The ingestion date should be set in the middle of the work starting and ending dates.<br>(Because the concentration of the airborne radioactive material - iodine, the primary nuclide causing internal exposure - had decreased significantly after May, the ingestion date is defined as the middle day of the working period.) | [Plant manufacturers]<br>The first day of the emergency work at the Fukushima Daiichi Nuclear Power Plant should be set as the ingestion date for the first measurement. For the later measurements, the first working day after the previous measurement should be set as the ingestion date.<br><br>[TEPCO]<br>The ingestion date was set as a middle day of the work period for backup personnel (most of their work period was three days).<br><br>[Nuclear facility employers, etc.]<br>・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 ingestion date.<br><br>・For other workers except those above, doses were evaluated with WBC (NaI). The ingestion date was set in the middle of the work started date and the WBC measurement date.<br><br>[Nuclear facility employers, etc.]<br>The ingestion 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 ingestion date. Note, however, that in case of an accident, the accident date needs to be set as the ingestion date in principle.<br><br>・Data at the West Gate indicates that the concentration of I-131was on a linear declining trend in a logarithmic graph during the period from 19 March to the end of April 2011.<br><br>・For workers whose doses exceeded 250 mSv in June 2011, their internal exposure was evaluated as episodic ingestion on 12 March partly because they did not wear masks properly.<br><br>・Methods should be standardized to the TEPCO's conservative evaluation method if individual and specific radiation exposure situation is unknown.<br><br>・Any results of behavior research of individual workers may be taken into consideration. | Revised case: 192 workers<br><br>Variation range: -1.7 mSv to 48.91 mSv<br>Average: 5.9 mSv<br><br>Note that the number of workers may include overlap because several measurement methods were reviewed simultaneously. |

| Items | Evaluation method by TEPCO | Evaluation methods by primary contractors | Determinations by MHLW | Revisions of doses |
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| | | [Plant manufacturers]<br>・Workers working during the period from the date of the Great East Japan earthquake to 23 March 2011:<br>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 ingestion date.<br><br>The date of the earthquake - 15 March -> 15 March<br>16 March - 18 March -> 18 March<br>19 March - 24 March -> 24 March | ・The method for determining the ingestion date for the period up to 23 March is appropriate to some extent. However, the TEPCO's method is more appropriate because the ingestion trend does not necessarily follow that of ambient dose rate outdoors. | Revised case: 218 workers<br><br>Variation range: -0.4 mSv to 26 mSv<br>Average: 4.4mSv<br><br>Note that the number of workers may include overlap because several measurement methods were reviewed simultaneously. |

| Items | Approaches by TEPCO | Determinations by MHLW | Revisions of doses |
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| 1-2<br>Ingestion Date<br>(in Seismically isolated building) | ○ Workers who worked only in the seismically isolated building:<br>Workers who worked only in the seismically isolated building are considered as those who ingested radiation with average concentration chronically because of the reasons described below. The date of ingestion causing internal exposure is set as the middle date of the work period in the seismically isolated building, and internal exposure is evaluated conservatively as episodic ingestion.<br><br>a) Air conditionings with charcoal filters in the seismically isolated building worked normally, and the filters were replaced as appropriate. Dose rates in the building were low except several days after the hydrogen explosion at Unit 4 (around at 6:14 am) on 15 March 2011. These imply that drastic change in airborne concentrations in the building was less likely while workers were engaged in the work.<br><br>b) Workers did not wear masks while working in the seismically isolated building. This implies that exposure was caused by chronic ingestion, not by accidental ingestion due to reasons such as slipped masks.<br><br>Note that this concept applies also to female workers. | ・As with the outdoor workers, doses of workers who worked only in the seismically isolated building should also be evaluated under the assumption that internal exposure was caused by episodic ingestion with 12 March as the ingestion date. Readings of area monitoring in a room located in the back of the building do not necessarily accord with the variation of the average concentration of airborne radioactive materials in the building. | Revised case: 3 workers<br><br>Variation range: 26.01 mSv to 2.86 mSv<br>Average: 12.0 mSv<br><br>Note that the number of workers may include overlap because several measurement methods were reviewed simultaneously. |
| | ○ Workers who worked both in the seismically isolated building and outdoors:<br>The date on which the worker started outdoor work should be set as the ingestion date under the assumption that ingestion was more likely to occur on that day.<br><br>Workers were engaged in ingress/egress control near double-doors in the seismically isolated building without | ・The basic idea is that a conservative assumption should be made if any uncertainties are observed in the dose evaluation. Setting the ingestion date individually may not be considered appropriate at this time. The ingestion date should be specified in the same manner as for outdoor workers. | Revised case: 3 workers<br><br>Variation range: 26.01 mSv to2.86 mSv<br>Average: 12.0 mSv<br><br>Note that the number of workers may include overlap because several measurement methods were reviewed simultaneously. |

| Items | Approaches by TEPCO | Determinations by MHLW | Revisions of doses |
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| | masks on or, if temporarily, with a half-face type of masks on during the period from 12 to 16 March, during which ingestion was most likely to have occurred. Thus, the middle day of the work period in the seismically isolated building should be defined as the ingestion date, instead of the day on which workers started outdoor work afterwards.<br><br>Note that this concept applies also to female workers. | | |

| Items | Evaluation methods by TEPCO | Evaluation methods by primary contractors | Determinations by MHLW | Revisions of doses |
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| 1-3<br>Ingestion date and correction for Te132 | No description | [Nuclear facility employers, etc.]<br>The ingestion date was determined from behavior questionnaires. (Example)<br>For workers who worked in March, the date marking the end of the first one-fourth of the period between the starting date and the end of March should be defined as the ingestion date.<br><br>・At the same time, each internal exposure to I-132 and Te-132 is added by using a ratio of I-132/Te-132 in order to correct these two values. (Only for those whose effective doses from I-132 and Cs exceed 10mSv or above)<br><br>ratio of I-132/Te-1323/11-15 50%<br>3/16-17 40%<br>3/18-20 30%<br>3/21-25 20%<br>3/26-3/31 10% | ・To evaluate conservatively, 12 March or the work started date should be defined as the ingestion date for the work conducted by the end of April.<br><br>・Note that workers may possibly have been internally exposed to 10% of I-131 while the chemical properties of Te have been unknown.<br>The way of determining the ingestion date and the reduction rate by MONDAL will be considerably conservative when the current committed dose evaluation method is applied.<br><br>・If a work commencement date is used as the ingestion date, re-evaluation for Te would be less likely to be required because internal exposure to Te would be encompassed in the conservativeness of the date revision. | Revised case: 36 workers<br><br>Variation range: -9.24 mSv to 48.91 mSv<br>Average: 7.7 mSv<br><br>Note that the number of workers may include overlap because several measurement methods were reviewed simultaneously. |
| 2<br>Analysis code for residual rate inside body and ingestion scenario | ・The residual rate in the analysis code for evaluating committed dose, "MONDAL3" (National Institute of Radiological Sciences):<br>(The residual rate inside body in the analysis code "MONDAL3" should be used from a disclosure standpoint regarding the evaluation conditions of detailed measurement (JAEA) and the evaluation analysis code.)<br>(In the ingestion scenario, the residual rate should be calculated as one episodic | [Plant manufacturers]<br>Internal exposure was evaluated using MONDAL3, considering that it was caused by chronic (balanced or imbalanced) ingestion during the work period, if the ingestion date could not be identified for workers who worked on 24 March or later and whose working days were either continuous or intermittent. | ・Chronic exposure scenario is the scenario in which workers ingest radioactive materials every day. By contrast, episodic ingestion scenario is the scenario in which workers received significant internal exposure at the time of an accident.<br><br>・Survey results on general public indicated that correlation of ambient dose rate in the environment and the ingestion volume was low, and that the trend in | Revised case: 95 workers<br><br>Variation range: 23.0 mSv to 0.3 mSv<br>Average: 5.1 mSv<br><br>Note that the number of workers may include overlap because several measurement methods were reviewed simultaneously. |

| Items | Evaluation methods by TEPCO | Evaluation methods by primary contractors | Determinations by MHLW | Revisions of doses |
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| | ingestion at a time.) | | ingestion did not accord with the trend in environmental monitoring.<br><br>・An episodic ingestion model had been used for evaluating internal exposure of general public in Fukushima Prefecture by January 2012.<br><br>・Therefore, the internal exposure by the end of April 2011 should be evaluated using the episodic ingestion model on the work commencement date. | |

| Items | Evaluation methods by TEPCO | Evaluation methods by primary contractors | Determinations by MHLW | Revisions of doses |
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| 3<br>The evaluation method using NaI survey meters in the cases with WBC (PL) (conversion from effective doses) | ○ Evaluation method using NaI survey meters:<br>The NaI survey meters detect Cs on the entire body instead of I-131 depositing in thyroid once a certain amount of time has passed since ingestion. Therefore, the instrument will not be used for measurement in July and later.<br><br>[Evaluation method]<br>The evaluations are described as follows.<br>(i) Measurement and evaluation using NaI survey meters<br>(It is recommended that the measurement should be conducted within several days after workers left the Fukushima Daiichi Nuclear Power Plant, who had entered there during the period from March to early May.)<br><br>・Determine the thyroid dose rate S (μSv/h) by putting the head of a detector in a NaI survey meter on the lower part of one's thyroid cartilage (Adam's apple).<br><br>・Subtract the background dose rate (μSv/h) from the thyroid dose rate S to calculate radiation exposure dose at the thyroid inside the body (Bq) by multiplying it by the thyroid deposition conversion factor (Bq/(μSv/h))(Note).<br><br>(Note) The thyroid deposition conversion | [Plant manufacturers]<br>The thyroid deposition conversion factor was set to 30 (kBq/(μSv/h)). (From the Nuclear Safety Research Association web site. A numerical value from a NaI survey meter (Aloka TCS-171 Type:DBM)<br><br>[Nuclear facility employers, etc.]<br>The thyroid deposition conversion factor was set to 41.1 (kBq/(μSv/h)). (As a result of calibration with a phantom)<br><br>[Nuclear facility employers, etc.]<br>The thyroid deposition conversion factor was set to 40 (kBq/(μSv/h)). (A specified value of the TEPCO Kashiwazaki-Kariwa Nuclear Power Plant)<br><br>[Nuclear facility employers, etc.]<br>The thyroid deposition conversion factor was set to 39 (kBq/(μSv/h)). (A specified value of the TEPCO Kashiwazaki-Kariwa Nuclear Power Plant) | ・According to the document (studied by NSRA), the thyroid deposition conversion factor is set to approximately 3.0E+4(Bq/(μSv/h)) when the detecting part is contacted on one's throat part, and 4.0E+4 (Bq/(μSv/h)) when it is placed 1cm apart.<br><br>・The radiation source of the phantom used by TEPCO was a mixture of barium and cesium (Cs-137) to simulate I-131. Thus, the dose rate may be output a little higher than that of the actual I-131.<br><br>・Note that it is recommended that each calibration value for individual NaI survey meters should be used because each of the meters differs individually.<br><br>・Therefore, an individual calibration value (3.0E+4) can be used, and if it is not available, the document l value (4.0E+4) can be used. | No revisions. |
| | | [Nuclear facility employers power contractors, etc.]<br>・The "residual rate for entire body" was used to calculate the iodine residual rate inside body, instead of using the residual rate in thyroid. | The residual rate in thyroid should be used when measurement is conducted by placing a NaI survey meter on one's throat part. | Revised case: 6 workers<br><br>Variation range: 31.5 mSv to4.6 mSv<br>Average: 16.8 mSv<br><br>Note that the number of workers may include overlap because several measurement methods were reviewed simultaneously. |

| Items | Evaluation methods by TEPCO | Evaluation methods by primary contractors | Determinations by MHLW | Revisions of doses |
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| | factor is determined using a neck phantom.<br><br>・Divide the radiation exposure dose at the thyroid inside the body. By the thyroid residual rate to determine the ingestion radiation exposure dose (Bq).<br><br>・ Multiply the ingestion radiation exposure dose by the effective dose factor (mSv/Bq) to determine the committed effective dose (mSv). | | | |

| Items | Evaluation methods by TEPCO | Evaluation methods by primary contractors | Determinations by MHLW | Revisions of doses |
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| 4<br><br>Evaluation method using NaI survey meters in the case with WBC (PL) (to estimate I-131 measurements when they are not detected.) | Correct 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 evaluate it from the measurement result elapsed for a month or more from the ingestion date.<br><br>○ Evaluation with addition of correction based on statistical data (to evaluate effective dose from I-131):<br>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.<br><br>The following formula should be used for the correction.<br>Y = -0.4633X + 18843<br>Y: effective dose ratio (I-131/Cs-137)<br>X: ingestion date (a numerical value starting from 1 January 1900 which is defined as "1". Note that this evaluation method is applied for the following cases:<br><br>(I) Cases in which the dose rate obtained by the measurements of NaI survey meters apparently includes low percentage of the dose rate originated | [Plant manufacturers][Nuclear facility employers, etc.]<br>Evaluate internal exposure to iodine using the residual rate inside body in "MONDAL3" 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, the TEPCO's correction formula seems more reasonable because it is based on the actual measurements.<br><br>・All of the contractors should use the same method by standardizing to either one. | No revisions. |
| | | [Plant manufacturers]<br>Evaluate internal exposure to I-131 as zero when a measurement of the NaI survey meter is 0.00μSv/h. | Use the TEPCO's evaluation method because internal exposure to I-131 may possibly be underestimated when the primary contractor's method is used. | Revised case: 4 workers<br><br>Variation range: 2mSv - 2.9 mSv<br>Average: 2.3 mSv<br><br>Note that the number of workers may include overlap because several measurement methods were reviewed simultaneously. |
| | | [Nuclear facility employers, etc.][Plant manufacturers]<br>・Evaluate 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.<br><br>[Nuclear facility employers, etc.]<br>・When applying a ratio of I-131/Cs-137, define the half of a WBC (PL) measurement as that of Cs-137 and evaluate 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.<br><br>Presumably the TEPCO's evaluation method is more reliable because it is based on WBC (PL) measurements. | Revised case: 43 workers<br><br>Variation range: 25.8 mSv -1.2 mSv<br>Average: 7.1 mSv<br><br>Note that the number of workers may include overlap because several measurement methods were reviewed simultaneously. |

| Items | Evaluation methods by TEPCO | Evaluation methods by primary contractors | Determinations by MHLW | Revisions of doses |
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| | from I-131 deposited on thyroid.<br>(Example)<br>・Case in which the impact of body surface contamination cannot be ignored<br>・Case in which the impact of radioactivities of Cs-134 and 137 inside body cannot be ignored<br>・Case of improper measurement timing, such as when the measurement date of a NaI survey meter elapsed a month or more from the ingestion date.<br><br>(II) Cases in which the measurement was conducted only with WBC (PL), not with NaI survey meters (regular/off-line WBC inspections). | | | |

| Items | Evaluation methods by TEPCO | Determinations by MHLW | Revisions of doses |
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| 5<br>Correction range (measurement errors from WBC and others) | The measurement error of Canberra's WBC (NaI) is 25%.<br><br>The measurement error of Fuji Electric's WBC (PL) is also roughly 25%.<br><br>The indication error of NaI survey meters is generally within 20% based on JIS.<br><br>Even when the committed dose needs to be revised due to the revision of the ingestion date and others, the TEPCO considers that revising the recorded dose is not necessary if the measurement error falls within 20%. | ・Change of Cs residual rate over time differs from person to person for those who undertook the measurement at the time of this accident. However, the change in average turned out to be similar to that of the metabolic model of the standard person specified by ICRP.<br><br>・Uncertainties such as the ingestion date and residual rate can have a greater impact on evaluation of internal exposure than just a measurement error.<br><br>Therefore, it is not necessary to study the necessity of modifying recorded doses based on measurement errors. Considering personal differences in metabolism and uncertainty of the ingestion date, it is also not necessary to modify recorded doses below 1mSv. | If required for the revision of the dose evaluation method, committed dose should be revised when its variation range is equal to or more than 1 mSv. |

Attachment-3

List of workers whose committed doses were corrected to lower values

| Employers | Revision of doses | Reason for the revision | Remarks |
|---|---|---|---|
| Nuclear facility employers, etc. | A total of 15 workers<br>Correction range: -5.7mSv to -1.0mSv<br>Average: -1.9mSv | The ingestion date was revised to the work commencement date. Evaluation of internal exposure to Te was revised as well. | Data for a total of 36 workers were revised due to the reasons described in the left column.<br><br>Variation range: -9.24 mSv to 48.91 mSv<br>Average: 7.7 mSv<br><br>As a whole, doses were corrected to higher values<br>. |
| TEPCO | A total of 2 workers<br>Correction range: -9.24mSv to -0.89mSv<br>Average: -5.1mSv | The ingestion data was revised to a work commencement date. Evaluation of exposure to Te was revised as well. | |
| Nuclear facility employers, etc. | A total of 1 worker i<br>Correction range: -0.26mSv | The residual rate and WBC efficiency were corrected. The method for reading out factors was also revised. | |
| General contractors | A total of 7 workers<br>Correction range: -3.45mSv to -0.1mSv<br>Average: -2.1mSv | Failure to update the in-house records with the internal exposure measurements provided by TEPCO | |
| Plant manufacturers | A total of 2 workers<br><br>Correction range: -0.4mSv to -0.02mSv<br>Average: -0.3mSv | Reported incorrect dose records to TEPCO.<br>Errors in calculation | |
| Total | A total of 27 workers<br><br>Correction range: -9.24mSv to -0.02mSv Average: -0.2mSv | | |

List of additional workers whose committed doses exceeded 100 mSv

| Employer | Revision of doses | Reasons for the revision | Description of work<br>date when workers were taken off radiation work) |
|---|---|---|---|
| 3 employees of TEPCO | (i) 99.87→148.78 mSv<br>(Committed dose 61.00 mSv→109.91 mSv) | Ingestion date was revised. | Work: Operator of the reactors No.1 and No.2 Reactor operator of Unit 1 and 2<br>The last date entering the area: 5 October 2011 |
| | (ii) 92.83→102.69 mSv<br>(Committed dose 28.4 mSv→38.26 mSv) | Ingestion date was revised. | Work: Radiation administration The last date entering the area: 11 June 2012<br>(5.5 mSv after December 2011) |
| | (iii) 94.44→101.83 mSv<br>(Committed dose 14.98 mSv→22.37 mSv) | Ingestion date was revised. | Work: Radiation administration<br>The last date entering the area (Fukushima Daiichi):<br>5 October 2011<br>(December 2011 and later, 0.12 mSv (other nuclear power plant) |
| 3 employees of contractors | (iv) 79.67 mSv→102.17 mSv<br>(Committed dose 33.6 mSv→56.1 mSv) | Ingestion date was revised. Exclusion of Te correction | Work: Electrical construction project management<br>The last date entering the area: September 2011 |
| | (v) 91.70 mSv→123.20 mSv<br>(Committed dose 47.2 mSv→78.7 mSv) | Ingestion date was revised. Exclusion of Te correction | Work: Electrical construction project management<br>The last date entering the area: November 2011 |
| | (vi) 99.23 mSv→106.93 mSv<br>(Committed dose 10.1 mSv→17.8 mSv) | Ingestion date was revised. | Work: Installation of water pumps in Unit 3 and 4The last date entering the area: 25 March 2011 |

(Note) Currently, no one is engaged in radiation work.

Cases that required correction due to errors in calculations and others

| Employers | Summary of errors in calculations | Summary of corrected doses |
|---|---|---|
| Nuclear facility employers, etc. | Errors when inputting factors such as effective dose factor, the lower detection limit, cesium/iodine ratio used for iodine correction calculation | 4 cases in total<br>Correction range: 13.1 mSv to +0.24 mSv |
| General contractors<br>Nuclear facility employers, etc. | Failure of TEPCO to send internal exposure measurement results to primary contractors | 6 workers in total<br>Correction range: +2.13 mSv to 0.01 mSv |
| Shipping contractors | Misidentification with other employee's data | 1 worker in total<br>＋13.2 mSv |
| Nuclear facility employers, etc. | Failure to update the in-house records with the internal exposure measurements provided by TEPCO | 8 workers in total<br>Correction range: ＋18.07 mSv to 2.16 mSv |
| General contractors | Failure to update the in-house records with the internal exposure measurements provided by TEPCO | 9 workers in total<br>Correction range: - 3.45 mSv to ＋1.34 mSv |
| Plant manufacturers | Error in the measurement reported to TEPCO | 1 worker in total<br>Correction range: - 0.4 mSv |
| Total | | 29 workers in total<br>Correction range: -3.45 mSv to18.07 mSv |