Commentary

New Standard Limits for Radionuclides in Foods

Institute for Integrated Radiation
and Nuclear Science, Kyoto University,
Tomoyuki Takahashi

Examination of a new standard limits for radionuclide concentration in food to replace the provisional regulation value set immediately after the accident at Fukushima Daiichi Nuclear Power Plant of Tokyo Electric Power Company (Inc.) caused by the 2011 Earthquake off the Pacific Coast of Tohoku was conducted by the Committee on Countermeasures against Radioactive Materials established within the Food Safety Commission of the Pharmaceutical Affairs and Food Sanitation Council of the Ministry of Health, Labour and Welfare. The new standard limits came into effect on April 1, 2012. This paper outlines the timeline until the establishment of the new standard limits and the views on the derivation of the new standard limits.

I. Introduction

The accident at Fukushima Daiichi Nuclear Power Plant of Tokyo Electric Power Company (TEPCO) caused by 2011 Tohoku earthquake off the Pacific Coast of Tohoku led to release of a large quantity of radionuclides into the atmosphere and the ocean. As this accident had a possibility of causing high-concentration radionuclides to accumulate in food, the Ministry of Health, Labour and Welfare (MHLW) set provisional standard limits for intake restriction of radionuclides in food and drink in “On disaster prevention measures for nuclear facilities”[1)] (Hereinafter referred to as “Nuclear Emergency Preparedness Guide”) of the Nuclear Safety Commission and notified local municipalities to restrict intake of food according to Article 6-II of the Food Sanitation Act on March 17, 2011[2)]. Following this, examination of new standard and criteria to replace the provisional regulation value was conducted by the Committee on Countermeasures against Radioactive Materials established within the Food Safety Commission of Pharmaceutical Affairs and Food Sanitation Council of the MHLW (hereinafter referred to as the Committee on Countermeasures against Radioactive Materials), and on April 1, 2012, these new standard limits came into effect. This paper outlines the timeline until the establishment of the new standard limits and the views on the derivation of the new standard limits.

DOI : 10.15669/fukushimainsights.Vol.1.231

Originally published in Journal of the Atomic Energy Society of Japan (ISSN 1882–2606), Vol. 54, No. 9, p. 602–605 (2012) in Japanese. (Japanese version accepted: May 8, 2012)

II. Thought on the Index Value of Food and Drink Intake Restrictions in the Nuclear Emergency Preparedness Guide

The index value for the food and drink intake restrictions specified in the Nuclear Emergency Preparedness Guide used as the provisional regulation limits in the Food Sanitation Act[3)] set the thyroid equivalent dose of radioactive iodine to be 50 mSv per year and effective dose of radioactive cesium (including contribution of radioactive strontium) to be 5 mSv for its dose level. The guide uses this index value as the basis for judging whether its preventive measures should be taken or not (hereinafter referred to as "intervention dose level"). The guide derives radionuclide concentrations in food equivalent to this intervention dose level (hereinafter referred to as "inductive intervention concentration") and set them as the index value. In addition, uranium and major Trans-Uranium nuclides have their index values set.

Among these, ^{89}Sr, ^{90}Sr, ^{134}Cs, and ^{137}Cs are considered as the assessment subject nuclides for deriving the inductive intervention concentration of radioactive cesium. The nuclide composition for the assessment, ^{90}Sr and ^{137}Cs, are estimated to be 0.1 from the soil surface atmosphere concentration ratio at the Chernobyl Nuclear Power Plant Accident, and for ^{89}Sr, ^{90}Sr, ^{134}Cs, and ^{137}Cs, the representative proportion of formation in the case that the specific burn-up of the fuel of light-water reactor is 30,000 MWd/t. Moreover, food was divided into the following five categories of "drinking water," "milk/dairy," "vegetables," "grains," "meat, egg, fish, others," and 1 mSv per year was allocated for each category. Here, 0.5 is used as the ratio between the yearly average concentration and the peak concentration. In addition, people were divided into three age groups of adults, children, and infants, and assessment was conducted for each age group. "Vegetables," "grains," "meat, egg, fish, others" are unified at the same value as "vegetables," which had the lowest inductive intervention concentration. As a result, it was inferred that the index value for the food and drink intake restrictions of radioactive cesium were 200 Bq/kg for "drinking water" and "milk/dairy," and 500 Bq/kg for "vegetables," "grains," and "meat, egg, fish, others."

In Food Safety Basic Act, it is stipulated that preparation of policies related to ensuring the safety of food requires a food health impact assessment of food. However, the provisional regulation value set on March 17 were established without a health impact assessment of food by the food safety commission because "it is so urgent to prevent or suppress the adverse effect on human health and there is no time to assess the health impact of food in advance." Therefore, on March 20, after the notification, the MHLW requested the chairman of the food safety commission to conduct a food health impact assessment, and the chairman submitted "urgent summary on radioactive materials" to the minister on March 20. In this summary, it was stated that, with regard to radioactive iodine and radioactive cesium, "extensive safety measures are required to prevent radiation exposure from food," and "appropriate measures should be evaluated when necessary from the perspective of risk management." Moreover, it stated that "it is necessary to continue the food health impact assessment."

Note that on April 4, high concentration of radioactive iodine was detected in seafood. As the Nuclear Emergency Preparedness Guide did not specify an index value for radioactive iodine concentration in seafood, the regulation value was not set at this point. Therefore, the MHLW decided to apply the provisional regulation values of radioactive iodine used for vegetables to seafood, which is 2,000 Bq/kg, on April 5.

On April 8, the first meeting of the Committee on Countermeasures against Radioactive Materials was held. At this meeting, it was decided that the provisional regulation values should be kept for the time being and it is necessary to build a system for continuous analysis/assessment of various data toward the future examination of the standard limits.

III. Thought on Setting the Regulation Standard [3)]

As discussed above, the new standard limits were mainly examined by the Committee on Countermeasures against Radioactive Materials. Note that the new standard limits were decided to be according to Article 11 of the Food Sanitation Act. The thought on the new standard limits (hereinafter referred to as "the standard limits") will be discussed as follows.

1. Intervention Dose Level

The food safety commission reported the results of the food health impact assessment of the radioactive materials contained in food to the minister of MHLW on October 27. Its main points are as follows:

- The food health impact assessment of food considers that the possibility of human health influence by radiation arises when the additional accumulated effective dose over lifetime is ≥100 mSv.
- There is a possibility that children are more sensitive than adults (thyroid cancer or leukemia).
- It is difficult to comment on the human health influence of dose <100 mSv according to currently available knowledge.

In response to the above, it stated that, "considering the fact that the evaluation result is shown in the additional accumulated dose through lifetime into account, future risk management should be according to the detection situation of radioactive materials from food and the current state of Japanese food consumption habit." These values postulate that the additional exposure was given only from food. Moreover, these values are considered to be applied to the additional effective exposure dose based on the monitoring data for ingestion of food that contains radioactive materials, and not to the administrative limits for decreasing the exposure from food, also known as the intervention dose level.

According to this report from the food safety commission, on October 28, the MHLW stated that they would lower the yearly acceptable dose of radioactive cesium in food from 5 mSv per year to 1 mSv per year by April 2012, with the basic consideration for the new standard limits.

The Committee on Countermeasures against Radioactive Materials had already estimated the committed effective dose based on the monitoring result, and as a result, the effective exposure dose for the case of continuously ingesting food with median concentration (deterministic method) is estimated to be approximately 0.1 mSv per year in committed effective dose. Moreover, from the safety side estimation, even in the case of ingesting food with 90 percentile concentration (90% concentration from the lower end), the dose is estimated to be approximately 0.2 mSv per year. Thus, it was considered to be sufficiently low. However, according to the principle to maintain the dose as low as reasonably achievable, it decided that lowering the intervention dose level to 1 mSv per year is reasonable. This decision was according to the perspective to ensure the safety and security of the citizens still further, and on the fact that Codex Alimentarius Commission, which is an intergovernmental organization for setting the international standard of food, uses 1 mSv per year as the "intervention exemption level" that does not require intervention.

2. Regulated Target Nuclides

Regarding the regulated target nuclides in the setting of the standard limits, as the standard limits correspond to the long-term situation since April 2012, when over 1 year has passed since the accident, the nuclides with relatively long half-life by which long-term impact needs to be considered, should be targeted. Thus, the nuclides with half-lives of ≥1 year among the nuclides whose estimated values of release amount are published by the Nuclear and Industrial Safety Agency (NISA) [5] were selected for consideration. That is, ^{134}Cs, ^{137}Cs, ^{90}Sr, ^{106}Ru, ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{241}Pu are the regulated target nuclides. Considering that those other than radioactive cesium among them are expected to require a long time for their measurement, setting a regulation value to each of them and monitor their concentration in food is not realistic. Therefore, it was decided to set the limits that do not go beyond 1 mSv per year, which is the intervention dose level, by estimating the ratio of the concentration of these nuclides and the concentration of radioactive cesium (sum of ^{134}Cs and ^{137}Cs) and then adding the dose of these nuclides.

Note that ^{131}I whose half-life is 8 days was not included in the limits as it has not been discovered in food since July 15, 2011. Moreover, the nuclides that are not considered in this evaluation were judged to be unnecessary to set limits for them at this point as they are deemed to contribute little to the dose.

3. Estimation of Concentration Ratio of Radionuclides in Food

To derive the limit of concentration in food equivalent to the intervention dose level, it is necessary to estimate the ratio of nuclides other than radioactive cesium to radioactive cesium in food. The route of radionuclides released from a nuclear facility into the atmosphere to move into agricultural products is dominated by the “direct deposition pathway” caused by the direct deposition of radionuclides in the atmosphere on agricultural products, immediately after the accident. Note that this direct deposition route includes the route that the radionuclides deposited on the surface of leaves or on a tree and then absorbed into the body of the plant/tree moves into the edible part of that plant/tree. Meanwhile, at the point of time when the release from the nuclear facility is almost converged and the deposition amount from the atmosphere has decreased, the “root uptake pathway” that the radionuclides deposited on the soil of cultivated land are absorbed into the body of a plant through its roots and then move into the edible part becomes dominant. From the long-term perspective, it is important to assess this root uptake pathway.

Regarding livestock products, as is the case with the agricultural products, radionuclides are transferred to the grass or forage crop through either the direct deposition pathway or the root uptake pathway and then ingested by the livestock as their fodder.

The possible transfer pathways to the freshwater system, such as rivers, lakes, and marshes, include direct deposition from the atmosphere to the water of rivers, lakes, and marshes immediately after the accident or the radionuclides settled on the catchment area flowing into the water later. The radionuclides transferred into freshwater through these pathways are absorbed by the freshwater organisms in these rivers, lakes, or marshes.

Moreover, the pathways to seafood include the radionuclides either in the waste water generated in the facility during the emergency measures against the accident, released directly into the ocean, or in the radionuclides, released into the atmosphere. The latter component diffuses toward the ocean and gets deposited on the sea surface, which is later transferred to seawater then being absorbed by the marine organisms living in either the seawater or in the marine soil.

As these standard limits correspond with the long-term situation over a year after the accident, the root uptake pathway from the soil is deemed to be dominant among the transfer route of radionuclides to agricultural products (including the forage crop). Therefore, the nuclide concentration ratio in agricultural products can be estimated by multiplying the nuclide concentration ratio in the soil with the soil to agricultural products transfer coefficient ratio. For this concentration ratio in the soil, the concentration ratio for cesium rounded to the safety side is used for the nuclides whose concentration ratio in the soil are obtained in the radiation dose map prepared by the Ministry of Education, Culture, Sports, Science and Technology[6)], and those whose concentration ratios are not obtained were estimated using the ratio of release estimate by NISA. Moreover, for the nuclide concentration ratio in freshwater used for estimating the nuclide concentration ratio of drinking water and freshwater products, the nuclide concentration ratios rounded to the safety side were used for ^{90}Sr and ^{137}Cs whose actual measurements are obtained in the radiation dose map[6)], and it was estimated from the estimation of the concentration ratio in the soil and the solid–liquid distribution coefficient ratio for other nuclides. Note that transfer coefficient from the soil to agricultural products (including forage crop), transfer coefficient from fodder to livestock products, transfer coefficient from freshwater to freshwater products and solid–liquid distribution coefficient were used as the environmental transfer parameters of this evaluation. Regarding these parameter, according to the data acquired in Japan and the International Atomic Energy Agency report, the values on the safety side, that is, the value for which the concentrations of other nuclides are highly evaluated was selected, so that the concentration ratios of radioactive cesium to other nuclides are not underestimated.

However, the information on the quantity or composition of the radionuclides released directly from the power plant site to the ocean was scarce, and an evaluation using a detailed environmental monitoring data akin to that for the land is difficult. Therefore, the evaluation of radionuclide concentration ratio in seafood was conducted by assuming that the contributions made by the dose from other radionuclides and those made by radioactive cesium to be equivalent, i.e., by considering the total dose to be the double of the dose from radioactive cesium.

4. Food Category

Food was divided into the following four categories: “drinking water,” “food for infants,” “milk” and other “general food.” The reason why food for infants and milk are in different category is that the comment by the food safety commission that was stated that “The possibility that children are more susceptible than adults” was taken into consideration.

Moreover, no detailed categories were used for general food so as to minimize the effect of variations in individual eating habits, to make the limits easier to understand for the general public, and to make it consistent with the international views, such as that of Codex Alimentarius Commission.

The scope of these categories was also examined. For instance, the limit of tea leaves was set at 500 Bq/kg in the provisional regulation value but in the standard limits, the regulation standard of drinking water at the drinking stage after production and processing was applied. Moreover, for food whose ingredients were dried and normally ingested after being soaked in water among the general food, it was deemed appropriate to apply the limit for general food at the stage of original ingredients and at the stage of ingestion.

5. Age Category, etc.

Although three categories of age group were used for deriving the provisional regulation value, more precise age categories of "<1 years," "1–6 years," "7–12 years," "13–18 years" and ">19 years" were used for setting the standard limits. Moreover, the difference in the amount of food ingestion between male and female was also considered for all the categories other than "<1 years." In addition, pregnant women were considered to be in a separate category, making the total number of categories ten.

The food ingestion used for calculating the radionuclide concentration equivalent to the intervention dose level (hereinafter referred to as "the limit value") was set by referring to the research result of the national average. The intake of drinking water was set at 1 L/day for "<1 years" and 2 L/day for all other categories according to the World Health Organization (WHO) guideline.

6. Setting of the Regulation Standard Values

First, 10 Bq/kg, which is the guidance level of radioactive cesium in WHO drinking water quality guideline, was adopted as the regulation standard value for drinking water. This guidance level is sufficiently conservative, and although water exceeding the guidance level would trigger a follow-up research, it does not necessary mean that the water is unsafe to drink. This value is considered to be applied as the normal everyday operation condition for providing existing or new drinking water[2)].

The yearly dose allocated to food was obtained by subtracting the dose equivalent to this drinking water concentration (including contributions from other nuclides) from 1 mSv per year which is the intervention dose level. The limit value of food was derived using this yearly dose allocated to food, radionuclide concentration ratio in food, yearly intake of each food, internal exposure dose coefficient of each nuclide, and the contamination rate of food in distribution. The contamination rate of food in distribution was assumed to be 50% according to the actual measurement obtained from monitoring examination, etc. and the fact that much imported food is contained in the food distribution. Moreover, the same limit value was set for "milk" and "food for infants," and 1/2 of 100 Bq/kg limit for general food was adopted as their limit value, as the value that would not be influenced even if every food in distribution were contaminated. The nuclide concentration ratio in food was calculated by considering the physical radioactive decay of radionuclides, and the value at the point that the limit value becomes the smallest was obtained.

The category that has the smallest limit value after such a calculation was "13–18 year-old (male)" at 120 Bq/kg (note that the 3rd digit was rounded down to the safety side). According to these results, the Committee on Countermeasures against Radioactive Materials agreed on adopting the following as the standard limits of radioactive cesium during the meeting held on December 22, 2011: 100 Bq/kg for general food, which rounded down the smallest number of the derived limit value to the safety side, and 50 Bq/kg for food for infants and milk, which is 1/2 of 100 Bq/kg limit for general food. Moreover, transitional measures in some areas were required during the transition to the new standard limits to avoid confusion in the market.

The estimated value of actual exposure dose from radioactive cesium based on these new regulation standard values was 0.043 mSv per year when using the median concentration, and 0.074 mSv per year when using 90 percentile concentration. Thus, it was verified that the values are sufficiently low compared to the intervention dose level.

The new standard limits plan was submitted to the Radiation Council by the Minister of MHLW on December 27 and deliberations were held. The Radiation Council reported on February 16, 2012 regarding this standard limits plan: "there is no objection to formulate it as a technical standard from the viewpoint of the basic policy stipulated by Act on Technical Standards for Prevention of Radiation Hazard," however, they stated that "it is important to prepare the system for maintenance of measurement equipment and securing/training the staff to use them for the appropriate operation of the standard limit for food" [7]. Further, this report included the following opinions; setting new standard limits is unlikely to significantly improve the effectiveness of protection against radiation because the risk originating from food is already smaller than 1 mSv per year, the opinions of the stakeholders (people who are involved in this issue from various perspectives) should be taken into consideration as much as possible, it is important to appropriately conduct the risk communication that recognizes the fact that the upper limit of the risk is minute even when the limit is slightly exceeded, and enough consideration to children in protection against radiation is already taken even if special standard limits were not set for "food for infant" and "milk."

Moreover, public comments were accepted via Internet from January 6 to February 4, 2012, and 1,877 opinions were received. Among them, 1,449 opinions called for more strict limits, 819 demanded more consideration to be given to children, and 55 regarded the new standard limits to be too strict [2].

Following these steps, a joint meeting between the Committee on Countermeasures against Radioactive Materials and the Food Safety Commission was held on February 24, and the standard limits plan without a modification from the original plan was then adopted and decided to come into effect from April 1.

IV. Conclusions

The standard limits came into effect on April 1, 2012. It was reported in the media that radioactive cesium concentration in some foods exceeded 100 Bq/kg and their distribution was regulated. To obtain the safety and security of the general public in food regulation, it is important to pursue further improvement of examination system, prompt and sufficient information disclosure of examination results, continuous dose assessment of internal exposure, investigation and research on the transfer of radionuclides into food, and informing people about the thought on the regulation standard in the future.

References

1) Nuclear Safety Commission. On disaster prevention measures at nuclear facilities, etc., Nuclear Safety Commission. (Final Revision 2008). [in Japanese]
2) http://www.mh lw.go.jp, Accessed 6 May 2012.
3) Nuclear Safety Commission, Department of specialized disaster prevention measures for the surrounding area of nuclear power station, Environmental working group. On the index for intake restrictions food and drink. Nuclear Safety Commission 1998. [in Japanese]
4) Food Safety Commission. Assessment Report: Radioactive materials contained in food. Food Safety Commission 2011. [in Japanese]
5) Nuclear and Industrial Safety Agency. On the evaluation of the state of reactor cores of Unit 1, Unit 2 and Unit 3 related to the accident at Fukushima Daiichi nuclear power station of Tokyo Electric Power Company Holdings, Inc.,. (June 6, 2011 [Revised at October 20]). 2011. [in Japanese]
6) http://radioactivity.mext.go.jp/ja, Accessed 6 May 2012.
7) Radiation Council. On the ministerial ordinance to partially revise the ministerial ordinance

regarding the component regulation of milk and dairy products (Ministry of Health and Welfare, Ordinance Nr.52, 1951) and the partial revision of the standard limits of food and additive (Ministry of Health and Welfare, Announcement Nr. 370, 1959). (Report). 2012. [in Japanese]