

## Safety Regulations of Radioactive Waste Disposal in Japan

Hiroyuki SANADA<sup>\*1</sup>

Based on the Reactor Regulation Act, final disposal of radioactive waste is carried out by means of burial methods in accordance with the type of radioactive waste, the concentration of radioactivity, etc. in order to protect the public and the living environment from the risks arising from radioactive substances contained in radioactive waste. The NRA has been promoting the development of regulations concerning Category 2 radioactive Waste Disposal. In addition, regarding the regulation of the geological disposal, “Considerations to Ensure Nuclear Safety in Site Selection for the Final Disposal of Specified Radioactive Waste” was decided in accordance with the Basic Policy on the Final Disposal of Specified Radioactive Waste decided by the Cabinet in May 2015, based on the Final Disposal Act. This paper describes the safety regulation of radioactive waste in Japan.

**Keywords: geological disposal, intermediate depth disposal, pit disposal, trench disposal, site selection, safety regulation**

### 1 Introduction

Based on the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors [1], hereinafter referred to as the Reactor Regulation Act, final disposal of radioactive waste is carried out by means of burial methods in accordance with the type of radioactive waste, the concentration of radioactivity, etc. in order to protect the public and the living environment from the risks arising from radioactive substances contained in radioactive waste.

Radioactive wastes for final disposal are categorized into Category 1 radioactive waste and Category 2 radioactive waste according to the level of radioactivity for each type of radioactive material.

**Figure 1** shows the image of the disposal method according to radioactivity level.

Category 1 radioactive Waste Disposal (geological disposal) is a method of burying radioactive waste to exceed the upper limit of the radioactive concentration for intermediate depth disposal specified by the Cabinet Order for Enforcement of the Reactor Regulation Act.

Category 2 radioactive Waste Disposal involves intermediate depth disposal, pit disposal, and trench disposal shown in **Figure 1**. Pit disposal and trench disposal are methods for near surface disposal.

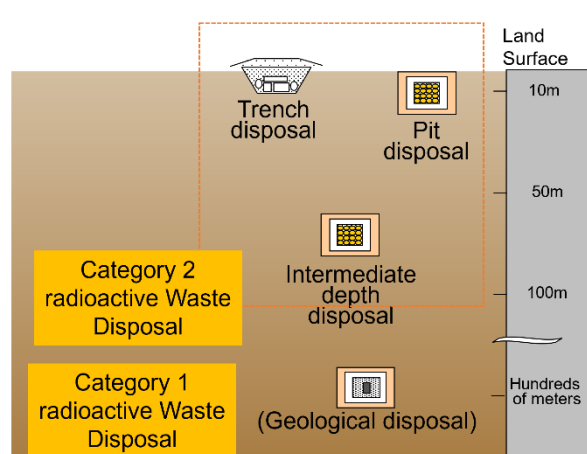
The NRA has been promoting the development of regulations concerning Category 2 radioactive Waste Disposal.

In addition, regarding the regulation of the geological disposal, “Considerations to Ensure Nuclear Safety in Site Selection for the Final Disposal of Specified Radioactive Waste” was decided in accordance with the Basic Policy on the Final Disposal of Specified Radioactive Waste decided by the Cabinet in May 2015, based on the Final Disposal Act (Designated Radioactive Waste Final Disposal Act) [2].

This paper describes the safety regulation of radioactive waste in Japan.

Since all safety regulation documents are written in Japanese rather than English, readers who wish to grasp the correct contents are encouraged to directly check the contents written in Japanese.

Furthermore, this paper is the author's personal view and not the organization's.



**Fig.1 Image of the disposal method according to radioactivity level**

### 2 Classification of radioactive waste disposal methods

Radioactive waste to be finally buried is subjected to geological disposal, intermediate depth disposal, pit disposal, and trench disposal according to the level of radioactivity for each type of radioactive material. Conditions such as activity concentration and disposal depth for each type of radioactive material specified for each disposal method are explained.

Those that exceed the standards specified for each type of radioactive material specified by Cabinet Order for Enforcement of the Reactor Regulation Act shown in **Table 1** shall carry out Category 1 radioactive Waste Disposal. In other words, the reference values shown in **Table 1** indicate the categories of Category 1 radioactive Waste Disposal and Category 2 radioactive Waste Disposal.

Radioactive waste that does not exceed the radioactive concentration for the radioactive materials specified in the NRA Ordinance on Cat-2 Waste Disposal Business for Nuclear Fuel Material or Objects Contaminated with Nuclear Fuel Materials in

Safety Regulations of Radioactive Waste Disposal in Japan by Hiroyuki, SANADA (sanada\_hiroyuki\_5mc@nra.go.jp)

\*1 Division of Licensing for Research Reactors, Use of Nuclear Material, Nuclear Regulation Authority, Japan  
1-9-9, Roppongi, Minato-ku, Tokyo, Japan 106-8450

This paper is added to the lecture content in ICRP International Symposium Satellite Event.

**Tables 2 and 3** shall be disposed of by the pit disposal and trench disposal, respectively. Near surface disposal of pit and trench disposal is located on the ground surface or up to 70 meters deep from the surface.

Intermediate depth disposal is a disposal method in which a repository is placed underground at a depth of 70 meters or more from the ground surface.

**Table 1 Classification standards based on the kind and quantity of each radioactive substance included in radioactive waste described in the Cabinet Order for Enforcement of the Reactor Regulation Act**

Carbon14	10PBq per ton
Chlorine36	10TBq per ton
Technetium99	100TBq per ton
Iodine129	1TBq per ton
$\alpha$ emitters	100GBq per ton

**Table 2 Concentration (upper) limit of pit disposal for each radionuclide stipulated in the NRA Ordinance on Cat-2 Waste Disposal Business for Nuclear Fuel Material or Objects Contaminated with Nuclear Fuel Materials**

Carbon14	100GBq per ton
Cobalt60	1PBq per ton
Nickel63	10TBq per ton
Strontium90	10TBq per ton
Technetium99	1GBq per ton
Cesium137	100TBq per ton
$\alpha$ emitters	10GBq per ton

**Table 3 Concentration (upper) limit of trench disposal for each radionuclide stipulated in the NRA Ordinance on Cat-2 Waste Disposal Business for Nuclear Fuel Material or Objects Contaminated with Nuclear Fuel Materials**

Cobalt60	10GBq per ton
Strontium90	10MBq per ton
Cesium137	100MBq per ton

### 3 Category 2 radioactive Waste Disposal

#### 3.1 Overview of the Licensing Standards

The NRA Ordinance on Standards for the Location, Structure and Equipment of Cat-2 Waste Disposal Facilities (the Licensing Standards) indicates the requirements for the location, structure and equipment of the repository, and for operational safety and long-term safety.

With regard to Articles 12 and 13, the review guide for waste disposal of Cat-2 waste disposal has been established as an

example of the method of confirmation by examiners in order to serve as a reference when examiners judge compliance with this provision.

The contents of this review guide are presented in a separate chapter.

Here, some examples of requirements are briefly described for some provisions.

Article 3 requires the ground of a facility having a safety function to be provided in a ground that can sufficiently support the facility having the safety function even when an earthquake force acts on the ground.

Article 4 requires that the earthquake can withstand earthquake forces sufficiently as a matter concerning the prevention of damage caused by earthquakes.

In addition, Articles 5 and 6 require matters concerning the prevention of damage caused by tsunami and damage caused by external hazards.

Article 8 requires that appropriate measures such as shielding must be taken in order to sufficiently reduce the dose in the vicinity of the site by direct gamma rays and skyshine gamma rays from waste disposal facilities.

Article 10 of retrievability of radioactive wastes requires only intermediate depth disposal and not trench and pit disposal.

Article 15 requires monitoring and measurement of groundwater levels, concentrations and doses of radioactive material in and around the site.

Article 16 requires, as matters concerning drainage facilities, the establishment of facilities for intermediate depth disposal in order to prevent the safety function of the buried site from being impaired by the submergence of ground water in the buried site during the period from the start of the acceptance of the buried radioactive waste to the end of the burial.

#### 3.2 Intermediate depth disposal

This chapter outlines the regulatory requirements for intermediate depth disposal based on description in the Licensing Standards, interpretation of the Licensing Standards and the Review Guide.

##### 3.2.1 Location of the disposal facility

(1) Faults etc.

In the interpretation of the Licensing Standards, it is required that the engineered barrier be installed to avoid the following faults.

i) Active faults that are considered to be the epicenter of faults whose activities cannot be denied after the late Pleistocene (about 120,000 to 130,000 years ago)

ii) Area damaged by the activity of the active fault described in i) above

iii) Among faults etc. whose activities cannot be denied after the late Pleistocene (from about 120,000 to 130,000 years ago), landslides which produce faults and displacements in which permanent displacement occurs due to earthquake activity

iv) Faults other than the faults i) and iii) above and having a large scale

Here, the area damaged due to active fault activity is described below in the Review Guide as a method for confirming the area.

Verify that the settings are configured in one of the following ways:

-It is set based on the survey result of the area where rock mass, etc. is damaged along the active fault to be considered as an epicenter.

-After evaluating the length of the active fault to be considered as the epicenter, the area within approximately 1/100 of the length from the fault plane is set.

In addition, as a method of determining large fault, the Review Guide states that there is no need to consider any of the following cases.

-The width of the damaged zone does not exceed about 20 to 30 centimeters.

-The cumulative displacement does not generally exceed the length from the top to the bottom of the waste disposal site.

#### (2) Volcanoes

Regarding volcanoes, it is required to install waste disposal sites avoiding the following locations:

- Locations where the histories of volcanic roads, dikes, etc. pertaining to volcanic activity in the Quaternary period (from present to about 2,580,000 years ago) where destruction of engineered barriers occurs due to the penetration of magma.

- Approximately 15 kilometers or less from the center of volcanic activity during the Quaternary period.

#### (3) Erosion

For erosion, the following is required.

-Even taking into account the 0.1 million-year depth reduction due to erosion, which takes into account sea-level fluctuations resulting from uplift and subsidence, and climate change resulting from increased or decreased continental ice sheet volume, it is required that at 0.1 million years, the ground surface projecting a waste buried site in a vertical direction should have a distance of 70 meters or more from the lowest point of the ground surface to the top of the waste buried site.

Here, when there is a river in the vicinity of the waste buried site, the erosion on the side where the valley width expands with the progress of the downward erosion is also considered, and when there is a shore, the erosion by the sea erosion is also considered.

#### (4) Mineral resources and geothermal resources

Mineral resources and geothermal resources require that mining of mineral resources or geothermal resources used for power generation is unlikely to take place.

### 3.2.2 Scenario evaluation

It is required that measures concerning the conservation of

disposal site will be shifted to a state in which no measures are required before the discontinuation of business is started.

Specifically, at 0.1 million years after the start of the discontinuation of business, it is required that the dose to be evaluated by the public does not exceed 20 mSv/year, based on the setting, assuming the approach of the public with radioactive waste, engineered barriers, soil and rock mixed with other materials.

In addition, this is required when a waste disposal site is installed in a place that is likely to be affected by erosion caused by sea-level fluctuations during the period from the start of business discontinuation until several 0.1 million years have elapsed.

In addition, based on the knowledge at the time of design, the basic design of the waste disposal site is required to satisfy the respective standards as a result of evaluating the effect of the buried radioactive waste on the public based on the natural event scenario and the borehole scenario.

Furthermore, in addition to the above, for intermediate depth disposal, in order to reduce the dose as much as possible in consideration of the large uncertainty in the evaluation of the dose received by the public, it is required to compare and examine the proposals of multiple designs and to develop designs with excellent performance for suppressing the transfer of radioactive materials.

### 3.3 Pit disposal and trench disposal

The basic design of waste disposal site requires that the impact of buried radioactive waste on the public after the commencement of business decommissioning be evaluated based on natural event and human intrusion scenarios to meet the respective standards.

Natural event scenarios require the most severe and most likely scenarios.

For the most severe scenarios, select the most severe radioactive material pathway within a scientifically reasonable range, and set the most severe parameters for the conditions of the engineered barrier and natural barrier within a scientifically reasonable range of combinations.

For the most likely scenario, the most likely route of radioactive material should be selected, and the parameters relating to the state of the engineered barrier and the natural barrier should be the most likely route.

Here, the criterion for evaluation under the most severe scenario is 300  $\mu$ Sv/year, and the criterion for evaluation under the most likely scenario is 10  $\mu$ Sv/year.

The period to be evaluated is 1000 years after the commencement of business decommissioning.

It is also necessary to confirm that the dose received by the public does not increase significantly over this period.

For human intrusion scenarios, based on a scenario that takes into account land use involving the excavation of waste disposal site immediately after the commencement of business decommissioning, it is required that the dose to be assessed by the

public not exceed 1 mSv/year for pit disposal and 300  $\mu$ Sv/year for trench disposal, respectively.

#### 4 Category 1 radioactive Waste Disposal

Based on the final disposal act, site selection of final disposal site will be carried out by stepwise approach like literature survey, preliminary investigations and detailed investigations.

In the Basic Policy on Final Disposal of Specified Radioactive Waste decided by the Cabinet Office in May 2015, it is stipulated that in order to rationally proceed with the selection of outline survey areas, etc., it is appropriate for the NRA to show considerations according to the progress for ensuring safety in site selection phases under the major premise that there will be no prejudice to the specific review of license application in the future safety regulations, etc.

As a result of the deliberations, the NRA decided in August 2022 that the following 1. to 4. should be considered as "Considerations to Ensure Nuclear Safety in Site Selection for the Final Disposal of Specified Radioactive Waste" for events that are difficult to deal with by designing final disposal facilities and that need to be dealt with by avoiding the establishment of final disposal facilities when selecting final disposal facilities.

1. Faults etc.
2. Volcanic phenomena
3. Erosion
4. Mining of mineral resources etc.

In considering the content of the considerations, the NRA, based on the radioactivity characteristics of high-level radioactive waste, organized the matters common to the regulatory standards for intermediate depth disposal and the matters that need to be additionally considered.

Considering the radioactivity characteristics of high-level radioactive waste, which requires a long period of time due to attenuation, compared with the waste subject to intermediate depth disposal, particular attention should be paid to volcanic phenomena that may cause radioactive waste to be released into the living environment and erosion that may cause a decrease in depth. Erosion may be dealt with by ensuring sufficient depth.

On the other hand, regarding the volcanic phenomenon, it is necessary to consider the possibility of a new volcano. From the viewpoint of confirming the latest scientific knowledge on the characteristics and regionality of the volcano occurrence mechanism in Japan, an opinion hearing meeting was held on the volcano occurrence mechanism, etc., and opinions were heard from the experts of the volcano.

#### References

- [1] Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors (1957) (in Japanese).
- [2] Designated Radioactive Waste Final Disposal Act (2000) (in Japanese).