

Deriving Safety Performance Indicator of Radioactive Waste Management Facility for Periodic Safety Review

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1. Introduction

The Safety Performance Indicator (SPI) is an indicator representing comprehensively the frequency of incidents, operational status of facilities, and radiation safety management in nuclear power plants (NPPs). Through these indicators, a rough assessment of the safety performance of NPPs can be obtained.

Currently, domestic NPPs have SPI developed according to the Periodic Safety Review (PSR) Safety Inspection Guidelines (KINS/GE-N018) [1], Section 8.3. However, safety performance indicators for radioactive waste management facilities (RWMFs) require development for each facility. In the Safety Review Guidelines for PSR of RWMF (KINS/GE-W006) issued in February 2023, Section 7.4 provides specific guidelines for SPI.

In this paper, we derived the ranges, categories, and indicators of SPIs applicable to RWMFs based on those used in domestic NPPs.

2. Safety Performance Indicator System of Domestic Nuclear Power Plants

The safety performance indicator system of domestic nuclear power plants is as shown in Table 1 [3], broadly divided into two ranges: reactor safety and radiation safety.

Reactor safety evaluates the number of incidents related to reactor safety, the reliability of systems to mitigate accidents, and the integrity of safety barriers to prevent the release of radioactive materials. As a result, reactor safety is categorized into three areas: safe operation, reliability of safety systems, and integrity of safety barriers.

The radiation safety range is categorized into two areas: internal radiation safety related to the protection of nuclear power plant workers and external radiation safety related to the protection of surrounding residents and the environment.

Within these categories, indicators are divided by category as shown in Table 1. Each indicator can be evaluated using a calculation formula to determine a score, which is then classified into four grades:

excellent, good, normal, and caution. The composition and significance of these grades are presented in Table 2, providing a visual representation of the evaluation results for all parameters, facilitating easy understanding of the safety performance of NPPs by the general public.

Table 1. Domestic Nuclear Power Plant Safety Performance Indicator System

Ranges	Categories	Indicators
Reactor Safety	Safety Operation	Unplanned reactor shutdown
		Unplanned power fluctuations
		Complex unplanned reactor shutdown
	Reliability of Safety System	Safety injection system
		Emergency generator system
		Auxiliary feed-water system
		Residual heat removal system
		Cooling water system
		Safety-related equipment failure
	Safety Barriers	Nuclear fuel integrity
		Primary coolant system integrity
		Containment building integrity
		Emergency measures
Radiation Safety	Internal Radiation Safety	Internal radiation dose
	External Radiation Safety	External radiation level

Table 2. Safety Performance Indicator (SPI) Grades and Meanings

State	Mark	Significance
Excellent	G	Adequately secured safety
Good	C	The safety is being maintained in a satisfactory state.
Normal	Y	The safety is fulfilled.
Caution	O	The state requiring monitoring and action

SPIs allow for quarterly monitoring of the safety performance status of all operational nuclear power plants in the country online. Additionally, users can access past safety performance indicators for specific reactors and view detailed evaluation information.

3. Safety Performance Indicator of Radioactive Waste Management Facility

In this section, we reference the safety performance indicators introduced in Section 2 for domestic nuclear power plants and derive applicable ranges, categories, and indicators for radioactive waste management facilities. This paper focuses on selecting a cave disposal facility as the designated site for the disposal of low to intermediate level radioactive waste [4].

Firstly, two main areas for ensuring safety in RWMFs have been identified: safety of radioactive waste management facilities and radiation safety. These areas have been delineated as follows, mirroring similar categories found in nuclear power plant SPIs:

- Safety of radioactive waste management facilities
- Radiation safety

Subcategories within the range of safety for radioactive waste management facilities have been identified as follows:

- Safety of radioactive waste management facilities
 - Facility integrity
 - System safety
 - Safety barriers

The category of facility integrity has been further subdivided into detailed indicators to evaluate the structural integrity of key components of the cave disposal facility, such as disposal tunnel, construction tunnel, and operational tunnel.

The category of system safety has been established to evaluate the key systems in the cave disposal facility, including drainage systems, ventilation systems, and other systems (such as fire, water supply, and power supply), classified into three indicators.

The safety barrier category has been classified into two indicators: surface contamination assessment of waste packaging containers such as 200L drums, and emergency measures.

The subcategories within the radiation safety domain have been identified as follows:

- Radiation safety
 - Internal Radiation Safety
 - External Radiation Safety

The subcategory of internal radiation safety within the facility evaluates the collective radiation dose of personnel in the RWMF, similar to NPPs. The indicator derived for this subcategory is the internal radiation dose within the facility.

Similarly, the category of external radiation safety evaluates the expected radiation dose to residents, also similar to nuclear power plants. The indicator derived for this category is the external radiation level outside the facility.

The delineated Ranges, categories, and indicators derived for the SPIs of radioactive waste management facilities are explicitly presented in Table 3.

Table 3. Waste Management Facility Safety Performance Indicator System

Ranges	Categories	Indicators
Safety of Radioactive Waste Management Facilities	Facility integrity	Disposal Tunnel
		Construction Tunnel
		Operational Tunnel
	System safety	Drainage System
		Ventilation System
		Other System
	Safety barriers	Surface contamination level of packaging container
		Emergency measures
Radiation Safety	Internal Radiation Safety	Internal radiation dose
	External Radiation Safety	External radiation level

The classification is set up similarly to the grades of safety performance indicators for nuclear power plants (Table 2), with quarterly evaluations planned for the radioactive waste management facility to present SPIs.

4. Conclusions

In this study, we derived the ranges, categories, and indicators of safety performance indicators applicable to radioactive waste management facilities based on those of domestic nuclear power plants. This provides a foundation for systematically evaluating the safety performance of radioactive waste treatment facilities, thereby facilitating more effective safety performance evaluations of RWMFs.

For future research, it is essential to consider deriving specific calculation formulas and grading criteria for the identified SPIs. This strategic evaluation process will enable us to assess the safety of RWMFs reliably and derive appropriate measures and improvement strategies based on these evaluation results.

REFERENCES

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