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Comparative Study on Monitoring Requirements and Guidelines of Site Investigation for Deep Geological Repositories

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NSE TECHNOLOGY

Contents

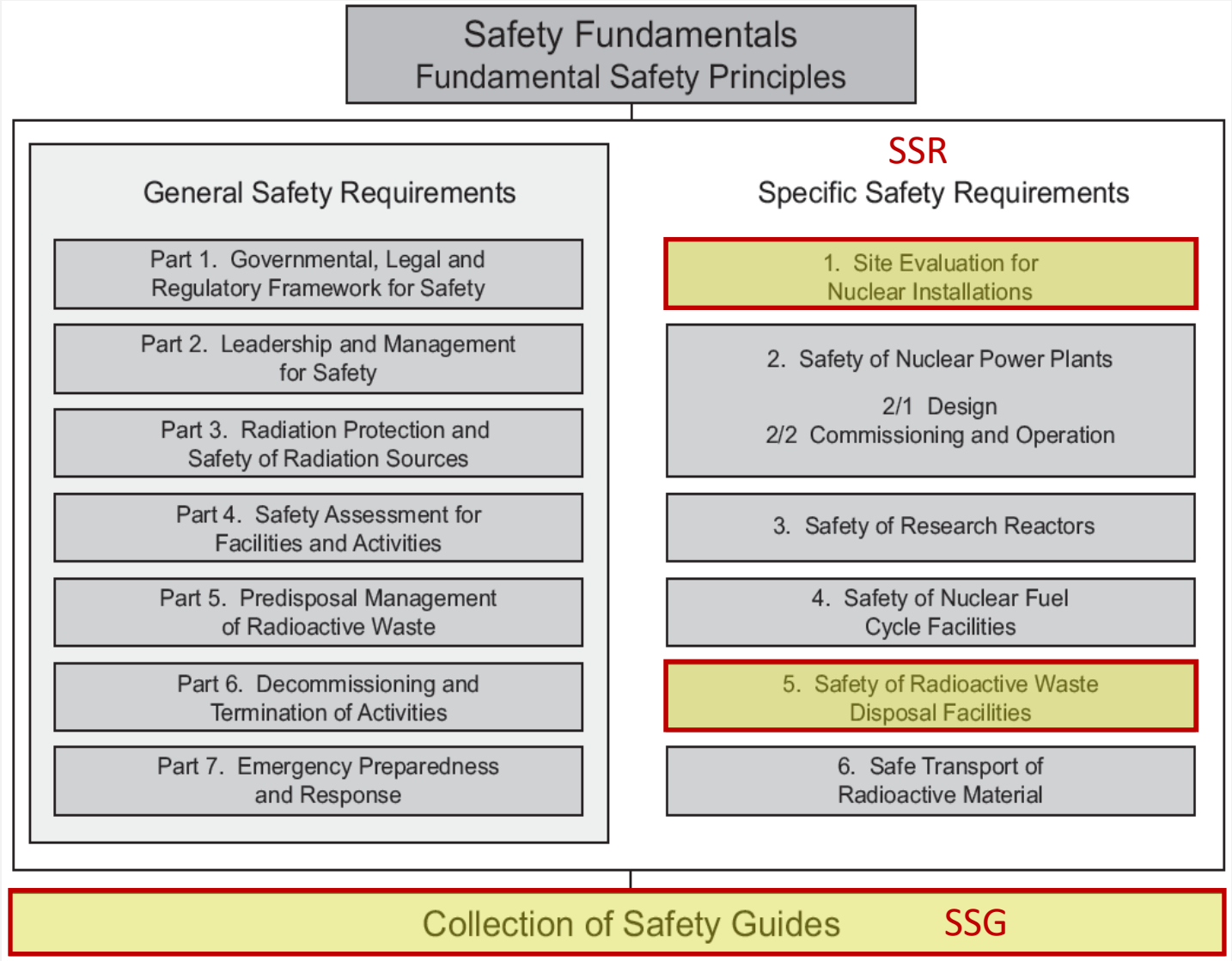
『Comparative Study on Monitoring Requirements and Guidelines of Site Investigation for Deep Geological Repositories』

1. Introduction

- **Research Projects in Progress (2024.04 - 2029.12)**
  - **‘Development of long-term environmental change prediction technology for high-level radioactive waste disposal sites’** (총괄과제: 고준위방폐물 처분을 위한 부지환경 장기변화 예측기술 개발)
  - **‘Development of monitoring and operational technique for site characterization factors in national/site scale’** (세부과제: 전국규모/부지규모 부지특성 인자별 감시기법 및 운영기술 개발)
- **Relevant Issues**
  - **The disposal of HLW from nuclear power plants is an urgent challenge.**
  - **Deep Geological Repositories (DGRs) are widely accepted as a safe and effective long-term solution.**
  - **Generic Safety Case needs to address the natural barrier for DGR licensing.**
- **Importance of Monitoring in Site Characterization:**
  - **Monitoring plans are key to establishing a baseline for construction, operation, and long-term post-closure safety.**
  - **These activities are subject to review and inspection under the independent regulatory framework.**
- **Study Objective:**
  - **Review and compare international and domestic monitoring requirements – scopes and methods - for early stages of site investigation and selection.**

2. International Standards

- Monitoring requirements and guidelines only for site characterization of potential DGR sites are not found as independent requirements,
- but as pre-operational requirements before the construction of the facility
- Multiple IAEA standards for monitoring requirements and guidelines regarding the siting or site characterization of DGRs,
  - Hierarchical framework,
  - Purpose of the facility, and
  - Basis for monitoring functions.



<Structure of the IAEA Safety Standards>

2. International Standards

2.1 Site Evaluation for Nuclear Installations, SSR-1

- Scope:
  - Applicable to all nuclear installations, including spent fuel storage facilities.
- Monitoring of external hazards and site conditions (Req. 28)
  - Monitor all natural and human-induced hazards and site conditions affecting safety and licensing.
- Monitoring plan:
  - identification of parameters, and type of data
  - data collection methods (location, frequency),
  - required resolution, and
  - data backup.
- Before commissioning, baseline measurements of background radioactivity for determining additional radioactivity in
  - atmosphere
  - water
  - soil
  - biota

2. International Standards

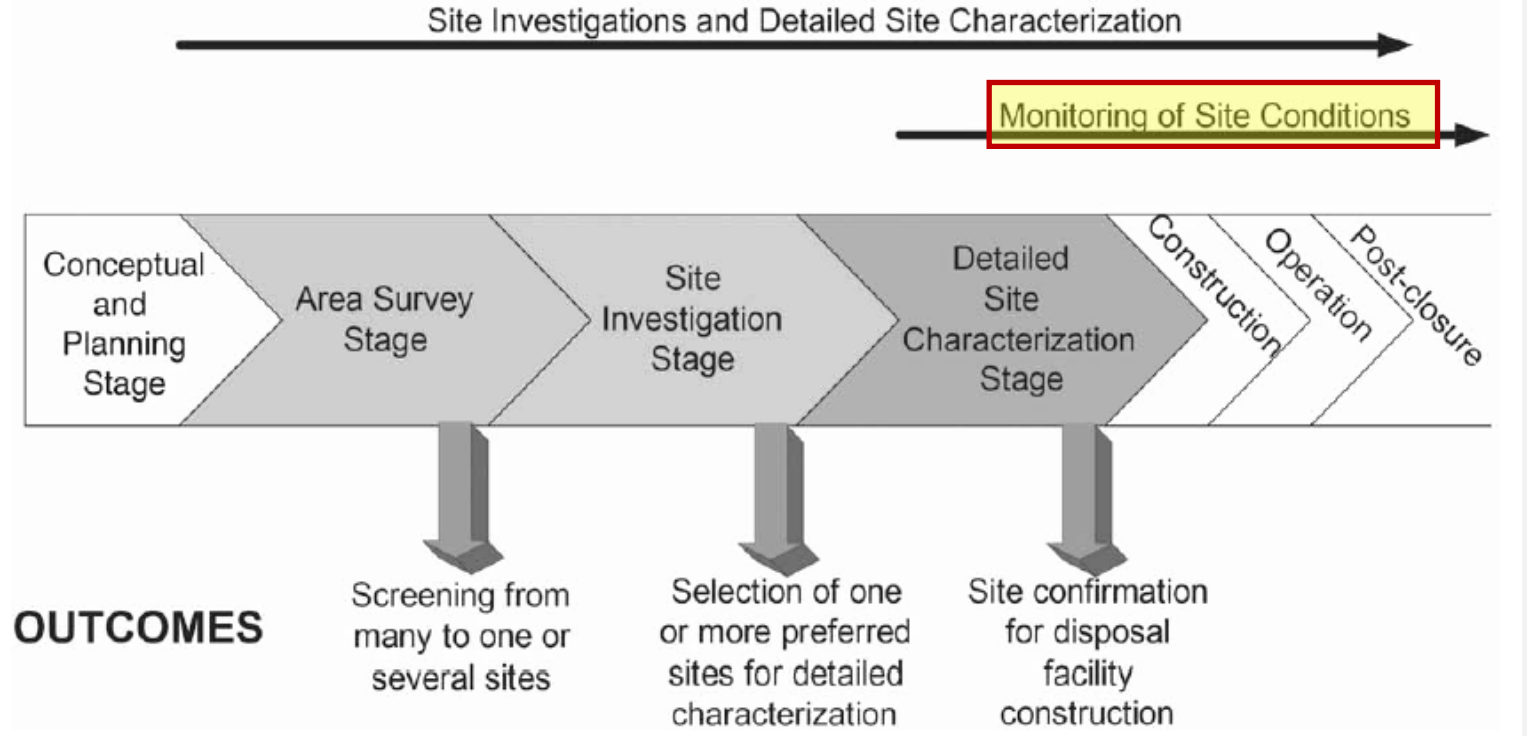
2.2 Disposal of Radioactive Waste, SSR-5

- Scope:
  - Focus on geological disposal facilities designed for HLW, including spent fuel.
- Site Characterization (Req. 15)
  - Emphasizes identifying geological, geomorphological, and topographical features and processes that affect safety.
  - Involves the measurement of natural background radiation and radionuclide levels in soil and groundwater.
- Monitoring Program (Req. 21)
  - Must be implemented before, during, and after construction.
  - Aimed at providing assurance of safety after closure required resolution.
  - Drawn up before the construction of a geological disposal facility
- Management Systems (Req. 25)
  - Requires robust data management systems to ensure the quality and long-term usability of monitoring data.

2. International Standards

2.3 Geological Disposal Facilities for Radioactive Waste, SSG-14 (1/2)

- **Purpose:**
  - **Offers guidance and recommendations for developing and regulating geological disposal facilities for meeting SSR-5.**
- **Stages of Site Characterization**
  1. **Conceptual & Planning Stage**
  2. **Area Survey Stage**
  3. **Site Investigation Stage**
  4. **Detailed Site Characterization & Confirmation Stage**



<Stages in the siting process>

2. International Standards

2.3 Geological Disposal Facilities for Radioactive Waste, SSG-14 (2/2)

- Guidelines of Monitoring
  - Include as data acquisition for site characterization
  - Begins early in the site investigation process and intensifies as development progresses.
  - Ensure a suitable baseline record of the natural systems of the site to determine any changes by the construction and operation of the facility.
  - Baseline data include hydraulic pressures, chemical constituents of waters, flow measurements, and natural background radioactivity.
  - Sampling interval should be selected to provide sufficient resolution to allow early notification of any significant changes in site conditions.
  - Characterization data include spatially distributed information and time series data to support the establishment of a baseline for future monitoring.
  - A baseline survey of the site, including the characteristics of the host rock, should be conducted before commencing construction activities.
  - The monitoring program should be subject to audit and independent verification for licensing.
  - Appendix I specifically addresses further details of site investigation and characterization guide, and data needs on hydrogeology and geochemistry.

2. International Standards

2.4 Monitoring and Surveillance of Radioactive Waste Disposal Facilities, SSG-31 (1/3)

- Purpose and Scope
  - Provides recommendations for monitoring radioactive waste disposal facilities.
  - Includes geological disposal facilities.
  - Covers monitoring and surveillance during the pre-operational, operational, closure, and post-closure periods.
- Objectives
  - Defining pre-existing contaminant levels before construction begins.
  - Enabling the evaluation of the waste disposal system.
  - Identifying parameters indicative of performance in the post-closure period.
- Site Characterization Activities:
  - Establish the natural characteristics of features, events, and processes occurring in the environment.
  - Develop baseline to identify trends and discern the facility's evolving impact.
  - Rely on instrumentation, visual inspections, sampling and analysis of samples, and data analysis and interpretation.
  - Conducted to establish a baseline and create a database of information on the surrounding environment.

2.4 Monitoring and Surveillance of Radioactive Waste Disposal Facilities, SSG-31 (2/3)

- Commencement of Monitoring
  - As early as possible, before the perturbations caused by the disposal facility.
  - In practice, the monitoring program will begin at the site investigation stage.
- Key Monitoring Parameters
  - Groundwater Systems:
    - Flow field and geochemistry in host rock.
  - Host Rock Properties:
    - Mineralogy, geomechanical stability, and radionuclide transport behavior.
  - Environmental Background Data:
    - Natural radioactivity in air, water, soil, and biodiversity.
  - Meteorology & Hydrology:
    - Climate conditions, surface water drainage, and infiltration rates.

2.4 Monitoring and Surveillance of Radioactive Waste Disposal Facilities, SSG-31 (3/3)

- **Data Management & Quality Assurance**
  - **Fidelity of Data:**
    - **Providing data in support of decisions that will be made over the entire lifetime of the facility.**
  - **Continuity in Data Collection:**
    - **Ensuring reliable records across the facility's lifetime.**
  - **Adaptability of Monitoring Programs:**
    - **Integration of new technologies for enhanced surveillance.**
  - **Transparency & Traceability:**
    - **Verification processes to maintain data integrity.**

3. Domestic Regulations and Guidelines

3.1 General Standard for Deep Geological Disposal Facilities for High-Level Radioactive Waste
(고준위방사성폐기물 심층처분시설에 관한 일반기준)

- **Delegated by**
  - **'Enforcement Decree of the Nuclear Safety Act'** (원자력안전법 시행령)
  - **'Regulations on Technical Standards for Radiation Safety Management'** (방사선 안전관리 등의 기술기준에 관한 규칙)
- **Scope:**
  - **General technical requirements for safety of DGR at phases including site investigation.**
- **Site (Article 9)**
  - **Located where the natural environment and socio-cultural characteristics** - such as the area's climatic conditions, surface conditions, distribution of surface and groundwater, and ecological features - **do not affect the safe operation of the disposal facility.**
- **Safety Analysis Report (Article 29)**
  - **Describes the site characteristics,** including the socio-cultural features of the region, climate, hydrology, geology, seismology, geotechnics, rock mechanics, geochemistry, natural resources, and ecosystems.
  - **Details the site safety evaluation and the site monitoring plans** before, during, and after the facility's operation and closure**.**

3. Domestic Regulations and Guidelines

3.2 Draft Notification for Guidelines on Preparing Site Characteristic Reports for HLW DGR (1/2)

(고준위방사성폐기물 심층처분시설 부지특성보고서 작성지침 고시(안))*

- **Reference Cases:**
  - **Regulatory requirements of the US, Finland, Sweden, and Switzerland were reviewed.**
- **Site Characteristic Report:**
  - **Must describe baseline information necessary to understand the characteristics of the disposal facility site.**
- **Required Site Characteristics:**
  - **geography and population,**
  - **facilities with the potential to cause human-induced disasters,**
  - **climatic characteristics,**
  - **surface water and marine characteristics,**
  - **geological characteristics,**
  - **hydrogeological characteristics,**
  - **hydrogeochemical characteristics,**
  - **rock mechanics and thermal characteristics,**
  - **contaminant migration characteristics,**
  - **and other environmental characteristics (human activities, ecosystems, and climate change).**

* 최종보고서 '고준위방사성폐기물 처분시설 부지특성 평가 및 조사를 위한 기준 개발', 1805020, KINS, 원자력안전재단 (2023).

3. Domestic Regulations and Guidelines

3.2 Draft Notification for Guidelines on Preparing Site Characteristic Reports for HLW DGR (2/2)

(고준위방사성폐기물 심층처분시설 부지특성보고서 작성지침 고시(안))*

- **Site Monitoring and Investigation:**
  - **site characteristic investigation and assessment items,**
  - **design,**
  - **and site characteristics relevant to long-term safety at each stage** (pre-construction, construction and operation, and post-closure)**.**
- **Reducing Uncertainties of the Site Characteristic Models:**
  - **Contents related to site monitoring and investigation should be presented to reduce the uncertainties of the site characteristic models.**
- **Quality Assurance:**
  - **The site characterization report must be based on objective data obtained according to an approved quality assurance system.**

* 최종보고서 '고준위방사성폐기물 처분시설 부지특성 평가 및 조사를 위한 기준 개발', 1805020, KINS, 원자력안전재단 (2023).

4. Concluding Remarks (1/2)

- International and domestic site monitoring requirements and guidelines are generally stipulated on the premise that DGRs will be constructed at the site.
- There are no independent requirements solely for site evaluation and monitoring without considering disposal facility construction.
- Recommendation: For monitoring of site investigations before determining a DGR site, it is necessary to selectively apply the suitable monitoring requirements specified for the pre-construction stage of DGRs.

- Korean domestic requirements and draft guidelines for site characterization have been developed with reference to foreign precedents. The monitoring scope and parameters are comprehensive and generally similar to international requirements and guidelines, but with more definite and extensive provisions.
- However, international standards provide more explanatory details regarding the background and rationale of site monitoring requirements and guidelines.
- Recommendation: Referring to these details when applying domestic standards can enhance the overall technical understanding of the requirements and guidelines.

4. Concluding Remarks (2/2)

- Site characterization assessments are conducted repeatedly from the pre-construction to post-closure stages and serve as essential components of the Safety Case.
- Example: Investigations into natural radiation backgrounds and radioactive nuclide content can be included, primarily to establish baselines for future comparisons.
- Recommendation: Site characterization assessments should incorporate monitoring parameters that are useful for baseline establishment during the site evaluation stage.

- Prior to construction, the monitoring program should focus on establishing a baseline for the site.
- Note: The domestic draft notification specifically requires that site monitoring should be planned to reduce the uncertainties of the site characteristic models.

- The disposal facility monitoring program needs to ensure data continuity and traceability, as well as the adaptability of data collection and interpretation, so that it can provide data to support decisions throughout the facility's entire lifespan.

ACKNOWLEDGEMENTS

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