The concept of safety case for geological disposal of high-level waste

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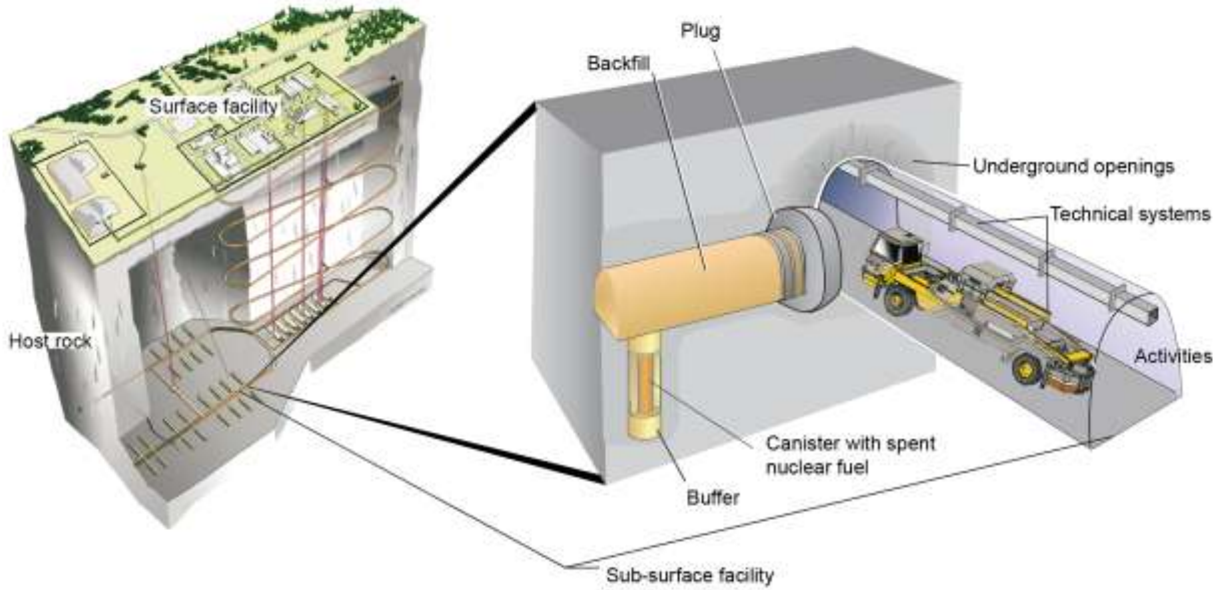
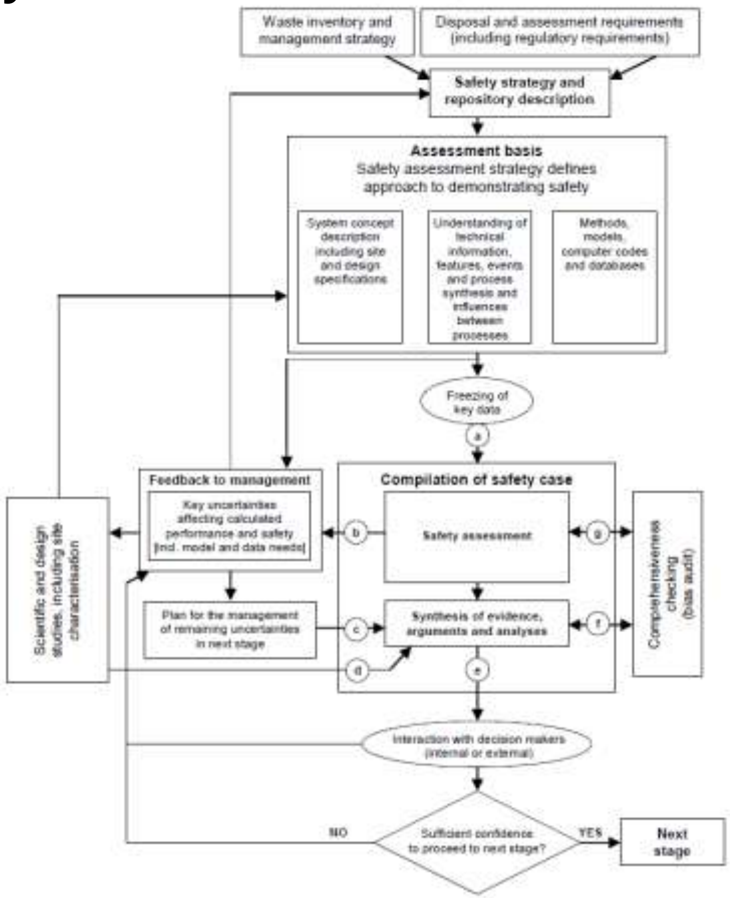
Deep Geological Repository (DGR)



- Disposal of long-lived radioactive waste in repositories, located in deep geological formations, is being investigated worldwide to protect humans and the environment;

Safety cases

- Safety Cases are instrumental for demonstrating long term safety of DGR



Background

- The concept of “safety case” was first introduced by the OECD / NEA Expert Group on Integrated Performance Assessment in the 90’s;
- In 1999, the NEA published a report on communicating confidence in technical aspects of a safety case: “*Confidence in the Long-term Safety of Deep Geological Repositories*”;
- The confidence report formulated the modern safety case concept. The Integration Group for the Safety Case (IGSC) was subsequently formed in 2000.
- IGSC Mission: to assist member countries to develop effective safety cases supported by robust scientific technical basis.

Background (cont'd)

2004 **NEA Brochure:** "Post-closure Safety Case for Geological Repositories"

2006 **IAEA Safety Requirements:** WS-R-4, using similar concept

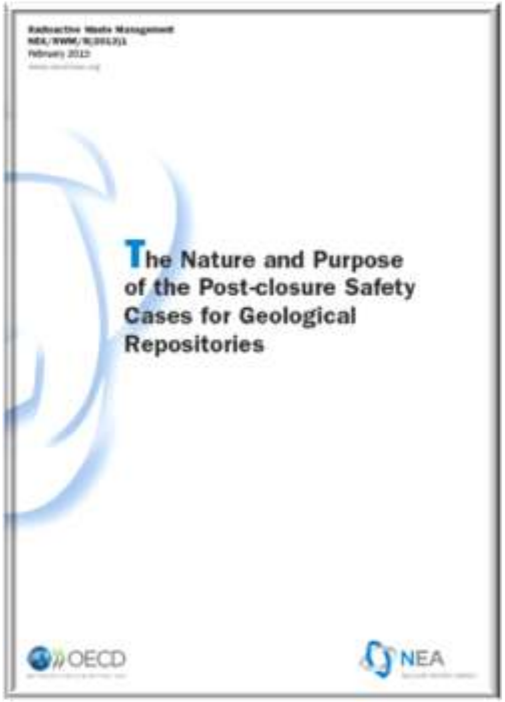
2011 **IAEA SSR-5:** states that a safety case is an explicit requirement for developing geological repository

EU Directive 2011/70/Euratom: consistence perception of a safety case

2012 **NEA updated brochure:** "The Nature and Purpose of the Post-closure Safety Cases for Geological Repositories"

2013 NEA Safety Case Brochure

- Focuses on addressing long-term safety;
- Defines the purpose, scope and content of safety cases for geological repositories for long-lived radioactive waste;
- Available at http://www.oecd-nea.org/rwm/reports/2013/78121-rwn-sc-brochure.pdf



The Safety Case and its Use

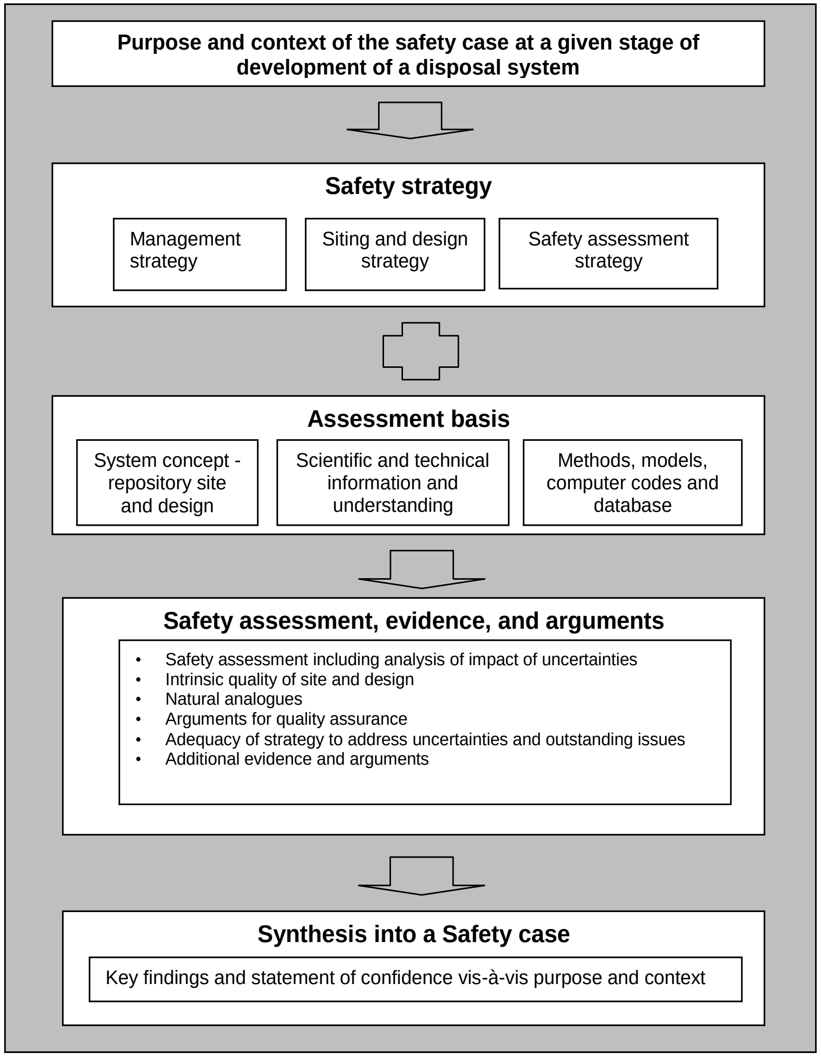
- A safety case is a formal compilation of evidence, analyses and arguments that quantify and substantiate a claim that the repository will be safe;

- A safety case has to demonstrate the possible evolutions and performance of a chosen site, its host rock, the engineered system is safe – bounded with confidence;

- A safety case is presented to support a decision, to help reviewing project status, to test safety assessment methods, or to prioritize R&D activities.

Safety Cases

- No universal format, key elements accepted worldwide are:
  - a statement of purpose and context,
  - safety strategy,
  - assessment basis,
  - safety assessment,
  - synthesis



Statement of Purpose

- Current stage of the development;
- Decision supported by the safety case;
- Type of information and level of details needed

Safety Strategy

- Management strategies to manage repository development;
- Siting and Design strategies to develop a reliable and robust repository system; multiple engineered barrier system;
- Assessment strategies to gather arguments and analyses; multiple lines of evidence.

Assessment Basis

- System concept – Modern safety cases use safety functions to provide more in-depth explanation;

- Scientific and technical information / understanding – descriptions of the various features, events and processes (FEPs), include the unexpected but plausible FEPs;

- Methods of analysis, computer codes, models and databases – to support modelling of the disposal system and its evolution. Include methods / strategies for building confidence (e.g. modelling) and evaluating uncertainties.

Safety assessment (SA)

- Role: To quantify the repository system performance, to evaluate confidence. Results of SA provide the required input to support decision making.

- While no standardized structure for SA, typical building blocks include:
  - Scenarios;
  - Modeling;
  - Outcomes of SA;
  - Handling of uncertainty

Scenarios

- Scenario – describe a potential evolution of the repository system from a given initial state; a basis for assessing safety by assessing the consequences;
- Scenarios are derived by compiling safety relevant FEP, map FEPs to the system safety concept and component safety functions;
- Conceptually described scenarios ➞ conceptual models ➞ mathematical models;
- Important to examine what scenarios could “endanger” safety functions

Modeling

- Models improve understanding of the processes + their relevance for safety. Modeling can demonstrate compliance;
- Models do not provide exact predictions, they illustrate possible ranges of system performance which support the safety case, i.e. multiple lines of evidence;
- Deterministic assessment - fixed, single-valued parameters;
- Probabilistic assessment – parameter values sampled at random from probability density functions (PDF);
- Probabilistic analysis is often used to assist the choice of data for deterministic calculations.

Outcomes of safety assessment

- Numerical results for specific safety indicators (e.g. potential dose / risk) + statements concerning uncertainty / sensitivity in calculations ➞ synthesis of evidence, analyses and arguments that quantify / support the safety case;

- Based on the available evidence, arguments and analyses, synthesis should show all relevant data have been considered, models tested adequately, a rational assessment procedure has been followed;

- Discuss limitations of the presented evidence, arguments and analyses;

- Revise the assessment or the design in cases of lack of confidence

NEA 2012, Indicators in the Safety Case: A Report of the IGSC, NEA/RWM/R(2012)/7

Characterizing and addressing uncertainties

- Reduce uncertainties by additional site characterization, engineering design, demonstration tests, experiments;
- Manage uncertainty with multiple lines of evidence;
- Avoid the sources of uncertainty or mitigate their effect by design modifications;
- Strategies for handling uncertainty:
  - Demonstrate the uncertainty is irrelevant;
  - Address the uncertainty explicitly;
  - Bound the uncertainty;
  - Rule out the event / process being uncertain;
  - Use an agreed stylized approach to avoid addressing the uncertainty explicitly
- Uncertainties and the potential of their reduction in future must be described in safety cases

Synthesis

- Summary of safety foundations;
- Uncertainties
- Statement of confidence

Statement of confidence

- Statement of confidence supports the views of the safety case authors;
- Must not presume confidence of audience;
- Must recognize outstanding issues and uncertainties.

THANK YOU

Current international situation

- NEA Safety Case Symposium, October 2013;
- Many NEA members are developing comprehensive safety cases;
- Members consider safety case a useful tool in achieving confidence and decision making;
- Considerations to establish credibility: transparency, traceability, openness;
- Peer review

Robustness and the multi-barrier principle

- Multiple components to isolate, prevent, delay potential releases;
- Complementary barriers, with diverse physical and chemical components and processes contributing to safety – to compensate for uncertainties in the system performance
- A system typically comprises the natural barrier and the engineered barrier system;
- Examples of complementary engineered system: canister, geochemical immobilization and retardation, slow groundwater movement by backfill

Quality assurance of the safety case

- A logical, clear and systematic approach;
- An auditable safety assessment (includes the development of computer codes);
- Continually improved safety approach;
- Independent peer review;
- QA plan must address the quality and management of all data, the manufacturing feasibility / constructability of the engineered components