KYT_SURFACE

Safety case for a near surface disposal facility

KYT Seminar 26.9.2019

Heidar Gharbieh, VTT

Contents

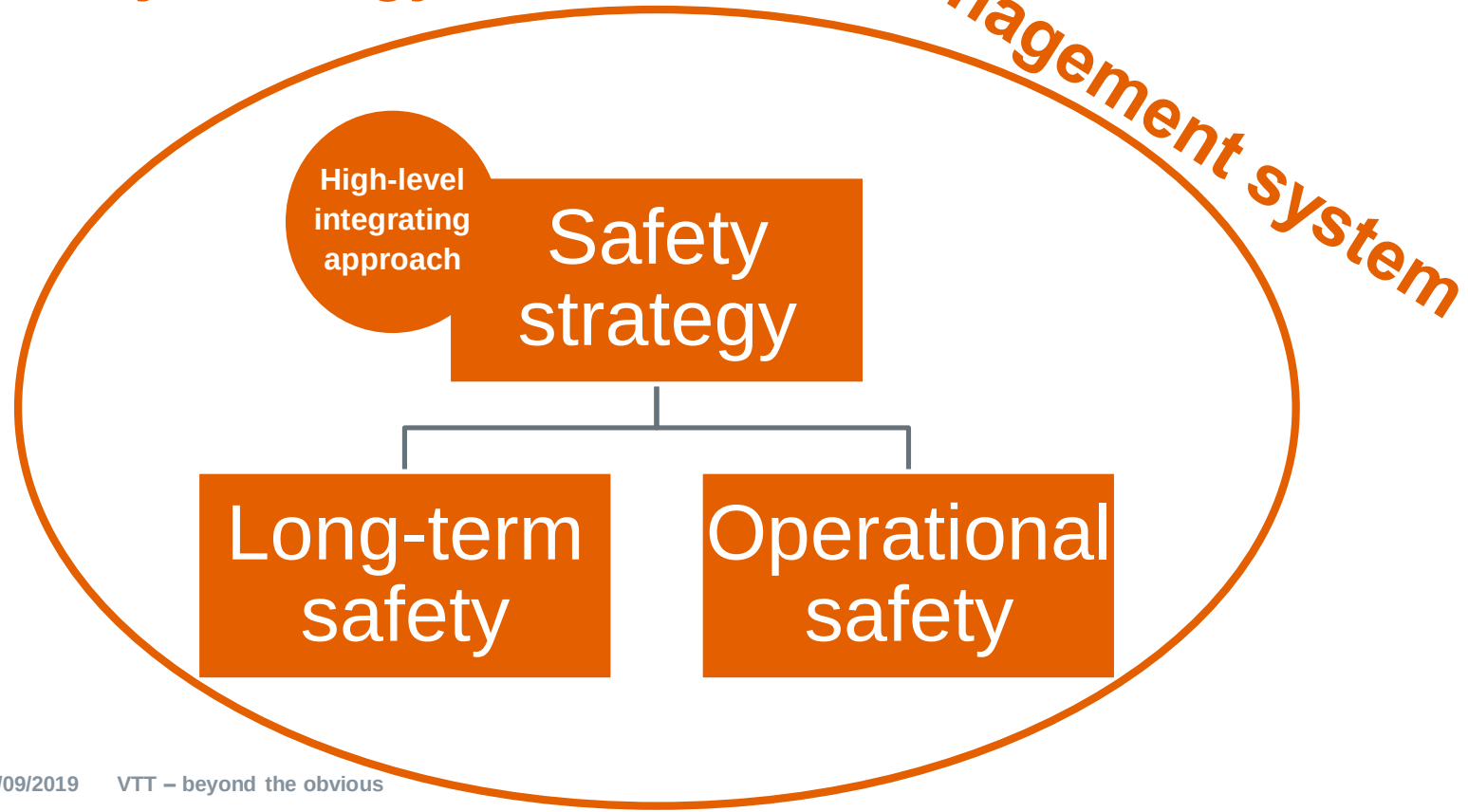
- Safety objective and safety strategy
- Safety case
- Safety assessment of a NSDF

Safety objective and safety strategy

Safety objective

- The fundamental **safety** objective of all nuclear facilities and activities during their entire lifetime or duration is to **protect** people and the environment from harmful effects of ionizing radiation (IAEA, 2006).

Safety strategy

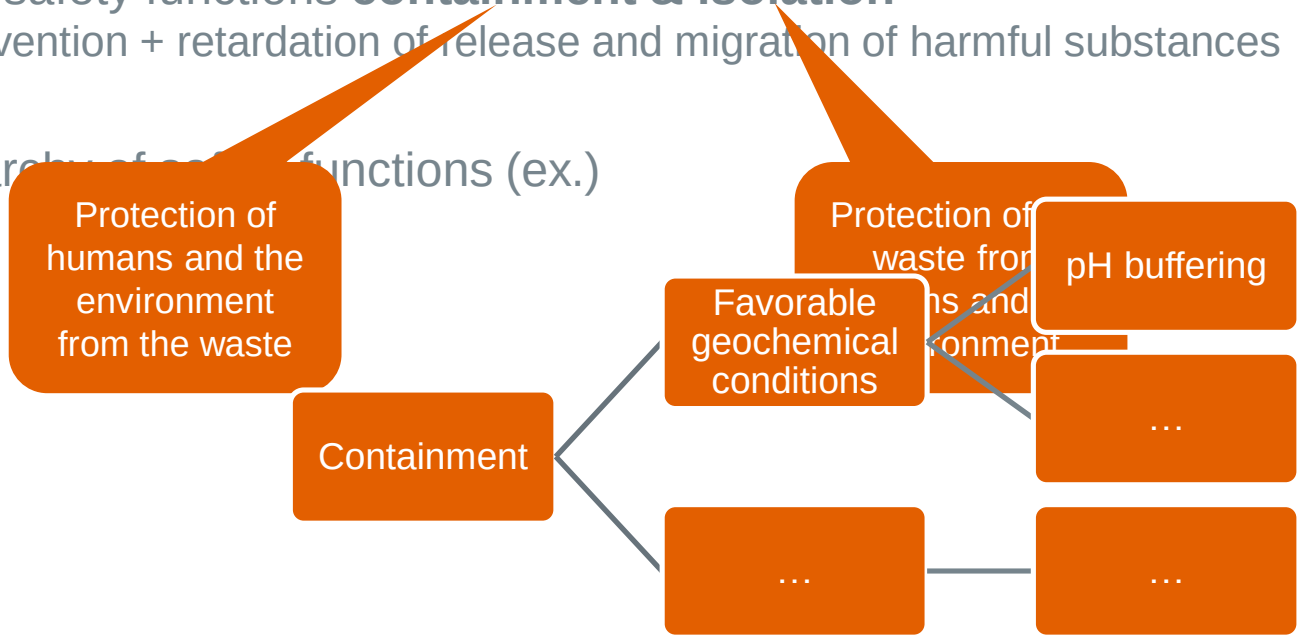


Safety strategy
Long-term safety

- Graded approach
  - Hazard
  - Stage of development
- Iterative and step-wise approach
  - New data, design updates
  - Flexibility (long-lasting process)
- No unduly reliance on active means
  - Institutional control
- Passive and intrinsic safety
  - Natural and engineered features of disposal system
  - Safety functions

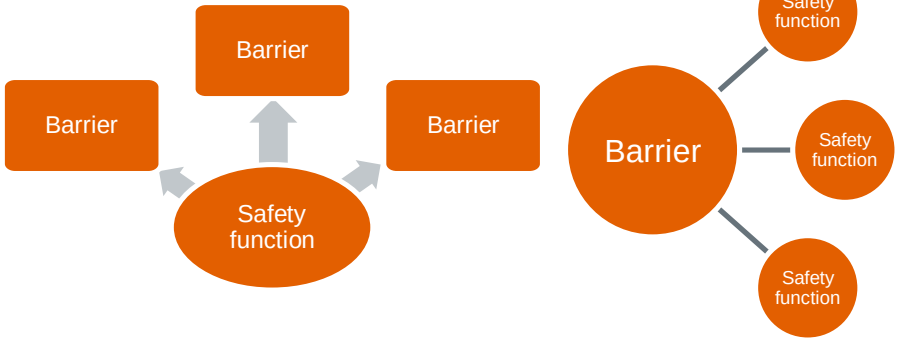
Safety strategy
Long-term safety – safety functions (1)

- Main safety functions **containment & isolation**
  - Prevention + retardation of release and migration of harmful substances
- Hierarchy of safety functions (ex.)

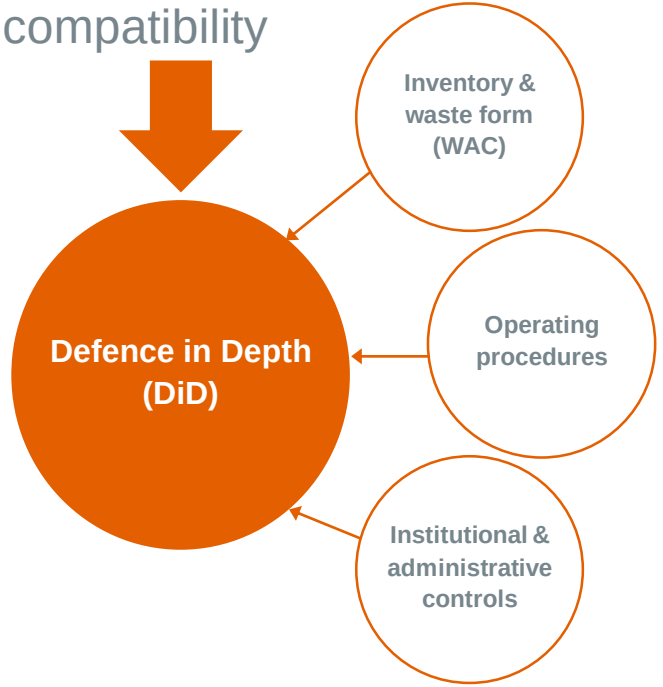


Safety strategy
Long-term safety – safety functions (2)

- Important during different time scales
  - Depending on repository concept and host rock



- Redundancy, diversity & compatibility



Safety strategy
Operational safety

- Passive means
  - E.g. radiation shielding
- Active means
  - Dose rate & surface contamination control (WAC)
  - Operating procedures (QC)
  - Monitoring of releases
- Safety assessments
  - Normal operating mode
  - Anticipated operational occurrences
  - Incidents & accidents
    - Internal (drop of waste package)
    - External (floods)
- Security, access control, safeguards, non-proliferation

Safety strategy
Management system

- Organizational aspects
  - Roles, responsibilities & authorities
- Safety culture
  - Safety as central and primary consideration
  - Questioning and learning attitude
  - Internal & external reviews
  - …
- Quality control (QC) & quality assurance (QA)
  - Supply chain
  - Operating procedures
  - Data mgmt. & record keeping
    - Uncertainty mgmt.
    - Assumption mgmt.
  - Resources (finance, personnel)
  - …

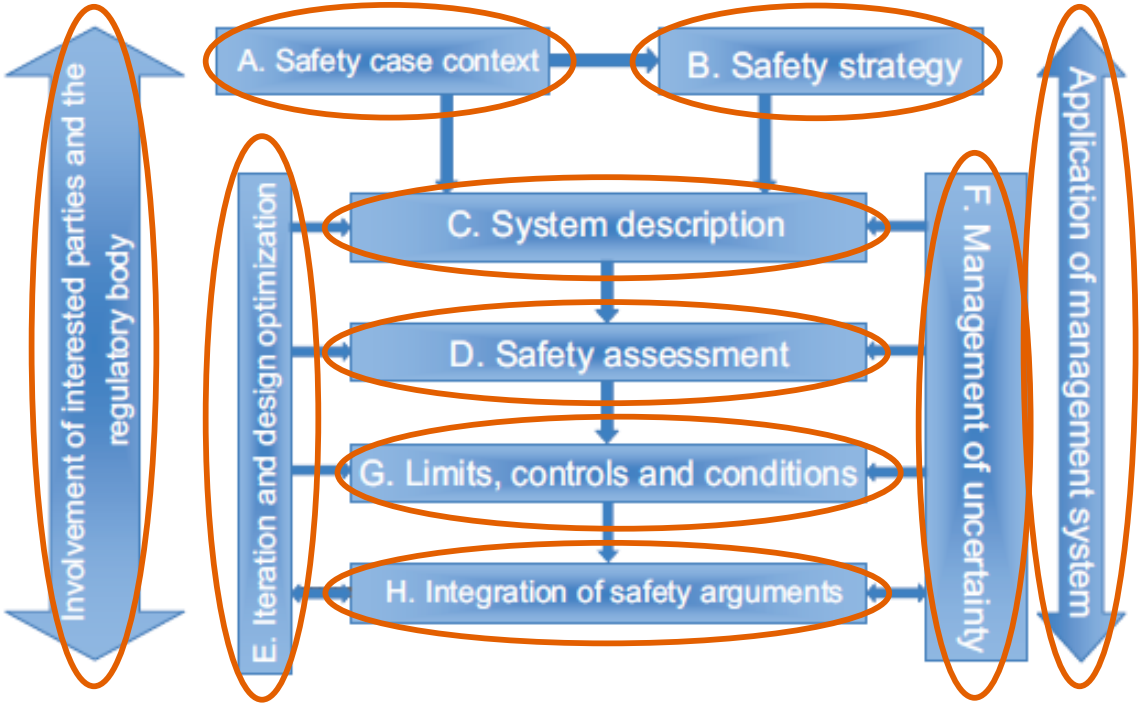
➢ Quality of all works and decisions

Safety case

Safety case

- Collection of scientific, technical, administrative and managerial arguments and evidence in support of the safety
- Suitability of the site and the design, construction and operation
- Assessment of radiation risks. Safety assessment is an integral part.
- Assurance of the adequacy and quality of all of the safety related work
- Basis for demonstration of safety, licensing and dialogue with interested parties

Safety case



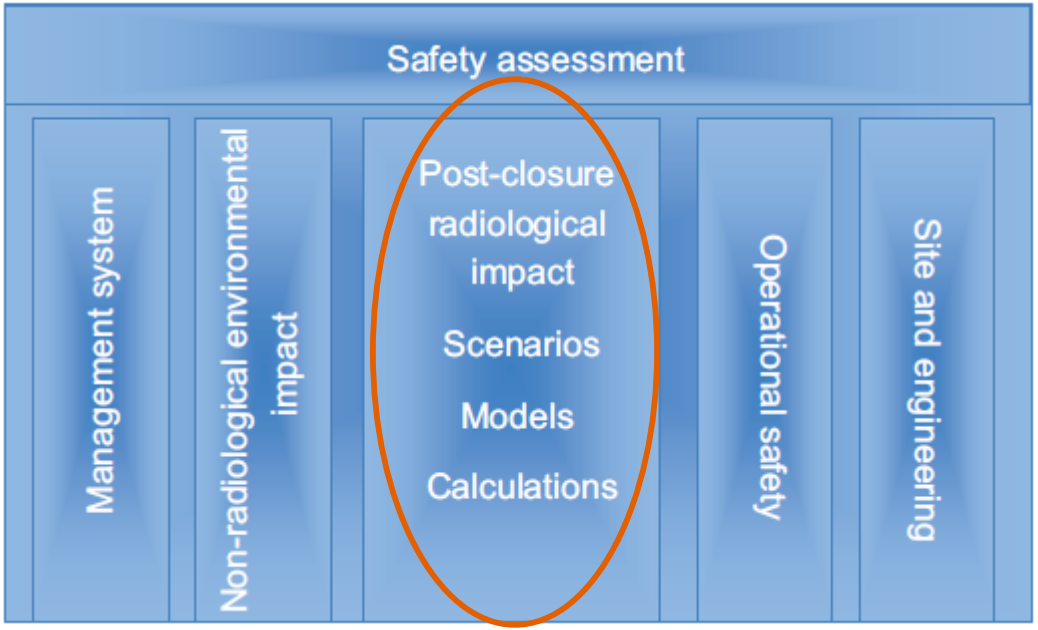
IAEA (2012)

Safety assessment

Safety assessment

- Safety assessment is the **main component of the safety case** and involves assessment of a number of aspects. The fundamental element of the safety assessment is the assessment of the **radiological impact** on humans and the environment in terms of both radiation dose and radiation risks. The other important aspects subject to safety assessment are **site and engineering** aspects, **operational safety**, **non-radiological impacts** and the **management system** (IAEA, 2012).

Safety assessment



IAEA (2012)

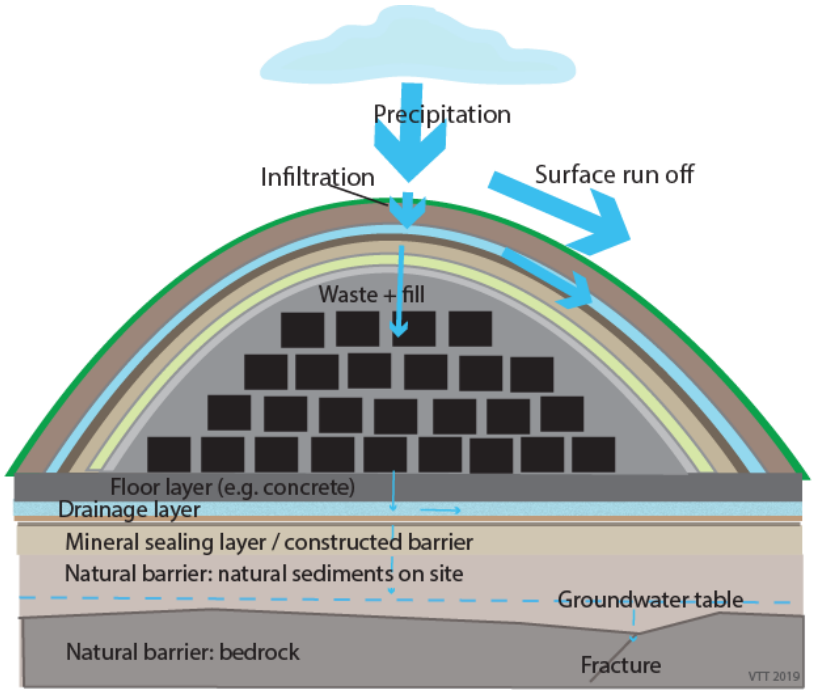
Scenarios
Institutional control period

- Predominance of short-lived radionuclides in NSDF
  - Timescale for safety assessments
  - Duration of institutional control period (active & passive)

- Active measures during institutional control period **do not** justify any undermining of the passive safety concept

- After the institutional control period
  - Safety of the disposal facility relies fully on passive measures
  - **Human intrusion** cannot any longer be excluded

Safety assessment
Migration modelling



1. Source term: Inventory, waste matrix and backfill
2. Transport in unsaturated zone
3. Transport in saturated zone
4. Radiological consequence (dose, risk), other safety indicators (e.g. concentrations, fluxes)

Safety assessment
Uncertainty management (1)

- **Scenario uncertainties** are associated with significant changes that may occur within the engineered and natural systems over time, and the uncertainties concerning physical and chemical processes accompanying those changes.

- **Model uncertainties** arise from an incomplete knowledge or lack of understanding of the behaviour of natural and engineered systems, physical processes, site characteristics and their representation using simplified models and computer codes.

- **Data and parameter uncertainties** are associated with the parameter values used in the implemented assessment models, since data may be incomplete, cannot be measured accurately or are not available.

Safety assessment
Uncertainty management (2)

- Reduction of uncertainties
  - Additional and more accurate data
  - Changes in design, WAC
  - Model development and alternative (conceptual) models
    - importance of modelling assumptions
    - fundamental understanding of important processes (→FEPs)

➢R&D program

- Treatment of uncertainties
  - Demonstrate irrelevance (very low probability or consequence)
  - “Stylized approach”
    - Biosphere, human behavior
  - Bounding/conservative calculation (models, data)
    - Justification for conservatism!
  - Probabilistic sensitivity analyses

Safety case
Integration of safety arguments

- Quality and reliability of the science and design work

- Quality and outcome of safety assessments
  - Scenario development, selection and quantification of their likelihood
  - Adequacy and quality of the methods, models, codes and databases
  - Uncertainty management

- Complementary evidence and arguments (DiD)
  - Appropriate management systems (QC)
  - Natural and anthropogenic analogues
  - Complementary safety indicators
  - Reserve FEPs

References

- **NEA, 2013**, The Nature and Purpose of the Post-Closure safety Cases for Geological Repositories, “Safety Case Brochure 2012”, NEA/RWM/R(2013)1, OECD/NEA, Paris. https://www.oecd-nea.org/rwm/reports/2013/78121-rwn-sc-brochure.pdf
- **NEA, 2019**, International Features, Events, and Processes (IFEP) List for the Deep Geological Disposal of Radioactive waste, Version 3.0, OECD NEA Radioactive Waste Management Committee, 165 p.
- **IAEA, 2002**, Scientific and Technical Basis for the Near Surface Disposal of Low and Intermediate Level Waste, Technical Reports Series No. 412, INTERNATIONAL ATOMIC ENERGY AGENCY, Vienna (2002).
- **IAEA, 2012**, The Safety Case and Safety Assessment for the Disposal of Radioactive Waste. Specific Safety Guide. IAEA Safety Standards Series No. SSG-23.
- **IAEA, 2014**, Near Surface Disposal Facilities for Radioactive Waste, IAEA Specific Safety Guide No. SSG-29, INTERNATIONAL ATOMIC ENERGY AGENCY, Vienna (2014).
- **STUK, 2018**, Guide YVL D.5. Disposal of nuclear waste, 39 p. + app 4, (https://www.stuklex.fi/en/ohje/YVLD-5)

beyond

the obvious

Heidar Gharbieh
heidar.gharbieh@vtt.fi
+358 40150 4766

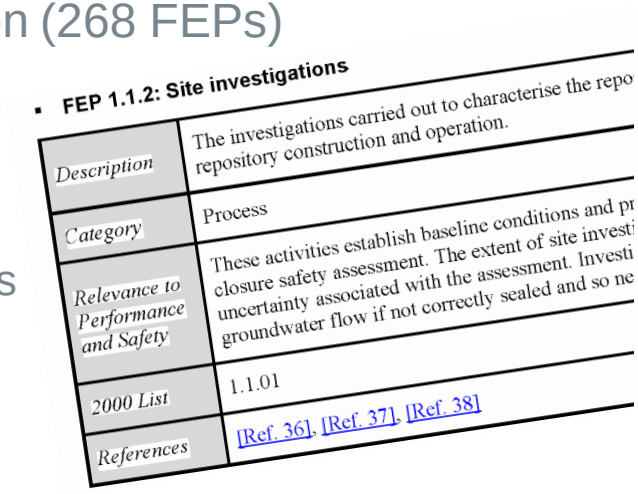
@VTTFinland

www.vtt.fi

27/09/2019

Scenarios
Features, Events & Processes (FEPs)

- FEP's are essentially possible/thinkable safety-relevant things that could happen in or near the disposal facility
- International and national compilations
- NEA (2019) compilation (268 FEPs)
  - external factors
  - waste package
  - repository
  - geosphere, and
  - biosphere related factors



FEP 1.1.2: Site investigations

Description	The investigations carried out to characterise the repo repository construction and operation.
Category	Process
Relevance to Performance and Safety	These activities establish baseline conditions and pr closure safety assessment. The extent of site investi uncertainty associated with the assessment. Investi groundwater flow if not correctly sealed and so ne
2000 List	1.1.01
References	[Ref. 36], [Ref. 37], [Ref. 38]

Table of contents

Scenarios
Definition (YVL D.5)

Origin of scenarios

- external factors, such as climate changes, geological events or **human actions**;
- radiological, mechanical, thermal, hydrological, chemical, biological and radiation-related factors internal to the disposal system; and
- quality non-conformances in the barriers, and the combined effects of all the aforementioned factors.

Scenario categories

- Base scenario: performance targets defined for each safety function are met.
- Variant scenarios: influence of declined performance of one or several long-term safety functions
- Disturbance scenarios: rare events impairing long-term safety, e.g. earthquakes, boring water well, infrastructure construction.

Scenarios
What-if cases

- Outside the range of possibilities reasonably expected to occur
  - physically possible or
  - not at all physically possible (e.g. removing entire EBS or no solubility limits)

- Illustrating the significance of individual barriers and safety function

- Demonstrating the robustness, resilience and integrity of the repository system