Working Group 1: Decision-Making and the EBS Design Process in the Safety Case

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Working Group 1

- Chair: **A. Hooper** (Nirex, UK)
- Rapporteur: **J. Bel** (ONDRAF/NIRAS, Belgium)
- Participants:
  - APTED, Mick
  - BENNETT, David
  - GUNNARSSON, David
  - JOHNSON, Lawrence
  - KAKU, Kenichi
  - KITAYAMA, Kazumi
  - MOHANTY, Sitakanta
  - PAKSY, Andras
  - PELLIGRINI, Delphine
  - SEVOUGIAN, David
  - Shyu, Yuan-horn
  - UEDA, Hiroyushi
  - UMEKI, Hiroyuki
  - VAHANEN, Marjut
  - WOLLRATH, Jürgen

WG1 – Decision-Making & EBS Design in the Safety Case

- **Optimization, Balancing Multiple Design Factors**
  1. What are the main safety functions addressed by the EBS over time? What methods exist for analysis of safety functions?
  2. How does one define and attribute safety functions and their indicators for EBS? How do process understanding, on safety indicators or functions, translate into design requirements?
  3. What factors are considered in EBS design, and how are they balanced? How are engineering feasibility, practicality, and cost balanced with respect to operational and long-term safety and other requirements?
  4. How are possible design alternatives selected, justified and managed?
  5. Is the concept of “best available techniques” applied and if so, how? By what criteria is “best” defined? How could the concept be interpreted over the timeframes for geologic disposal?

3. What factors are considered in EBS design, and how are they balanced? How are engineering feasibility, practicality, and cost balanced with respect to operational and long-term safety and other requirements? (1/2)

Optimisation process:

- Safety basis (pillars) has to be defined before optimisation
- No international, unique prescription for optimisation
- Depends on stage of program and it is an iterative process (in each stage optimisation can be considered but at different levels of detail)
- *Observation*: optimisation is difficult if important uncertainties remain
- A target and methodology is required to guide optimisation
- In some cases, design is modified to accommodate very low probability scenarios
- Ranking of system requirements (ranging from *musts*" to "*shoulds*" to "*nice-to-haves*") is essential to guide an efficient process
- Cost should not be the overriding driving force in the optimisation process

3. What factors are considered in EBS design, and how are they balanced? How are engineering feasibility, practicality, and cost balanced with respect to operational and long-term safety and other requirements? (2/2)

Decisional process:

- How formal does this decisional process has to be ?
    - Decisions should be well-documented
    - Depends on the stage of the program but framework is useful from the beginning
- Integration between engineering (design+construction) and safety analysis has to be achieved at each stage in the process (nature and level of integration depend on stage)
- Frequent review of the design is necessary (continual process)
- Be sure that all requirements have been considered
- Optimisation is a creative process
- While there is a clear need for record of decisions and for a requirement management structure, this does not provide the answer

4. How are possible design alternatives selected, justified and managed?

- Design alternatives exist to address different types of uncertainties (e.g. host rock, site conditions, process uncertainties,….)
- High level requirements should be well defined, justified and ranked; they may change (e.g. dose limits) as the program progresses
- Requirements will evolve as a consequence of changes in design
- Multiple methodologies exist to support the selection process (e.g. multi-criterion analysis) but it will always entail subjective judgement
- Re-evaluate design alternatives after each iteration of safety assessment or selective process analysis
- Prudent to carry alternatives in early stage

WG1 – Decision-Making & EBS Design in the Safety Case

- **Iterative Process, Relationship to Performance Assessments and Safety Assessments**

6. What are the roles of uncertainty and of sensitivity analysis in decision-making, and in establishing priorities for confirmation of performance ?
7. What are the criteria used to determine an adequate margin of safety, and how is this shown in view of the uncertainties?
8. What are the reasons and the procedures used to justify design modifications, or even a change to a different design concept? Based on what data? What are the lessons learnt from organizations that have already conducted such an iterative process?
9. How are the consequences of design changes incorporated back into Safety Assessment?

6. What are the roles of uncertainty and of sensitivity analysis in decision-making related to the design, and in establishing priorities for confirmation of the performance of the design ?

- Identify uncertainties in design parameters and environmental conditions, and incorporate these uncertainties through a set of sensitivity analysis
- Rank uncertainties through sensitivity analysis and "uncertainty importance"
- Identification of important parameters and associated uncertainties allows to define priorities for future program for the reduction of uncertainties in the important design parameters
- Sensitivity analysis may help in defining the degree of robustness of the design (***robustness*** is defined as the resilience of a design to the credible range of conditions it will experience)

7. What are the criteria used to determine an adequate margin of safety, and how is this shown in view of the uncertainties? Provocative question! (1/2)

- Margins of safety are not imposed by regulations and standards
- Margin of safety is not necessary if uncertainties are properly accounted for:
  - Uncertainties are typically included in the assessments
  - Assessments often use conservative assumptions
- Margin of safety ultimately has to be evaluated by the regulator
- Margin of safety (numerical indicator) is not the same thing as conservatism (approach)
- What margin of safety is needed to decide no further optimisation is required => depends on strategy of waste management agency regarding the safety case
- Safety relies more on the system robustness than on a safety margin
- No precise prescription of margin of safety seems necessary
- Difference between safety margin of overall system or performance margin of a given component

7. What are the criteria used to determine an adequate margin of safety, and how is this shown in view of the uncertainties? Provocative question! (2/2)

Rather than margin of safety, think of strength in depth:

- Reserve functions in the EBS-design
- Design tolerances in the EBS properties and characteristics

8. What are the reasons and the procedures used to justify design modifications, or even a change to a different design concept? Based on what data? What are the lessons learnt from organizations that have already conducted such an iterative process? (1/3)

- ***Possible reasons for modification***
  - Results from testing and characterization (lab, small or large scale, in situ)
  - Changes in the boundary conditions (waste inventory)
  - Scenario analysis and modelling
  - (Peer) reviews & comments from regulator or other stakeholders
  - New regulations
  - Change of candidate-sites
  - More general: changes in requirements give rise to modifications

8. What are the reasons and the procedures used to justify design modifications, or even a change to a different design concept? Based on what data? What are the lessons learnt from organizations that have already conducted such an iterative process? (2/3)

- ***Procedures used to justify design modifications*****:** need is self-evident
- Based on what data **?**
  - Exchange of information among engineering, geo-science and PA (e.g. effect of inflow on function of bentonite, potential for rock fall on function of canister integrity,…)
  - Important to keep records of the basis of comparison of the designs

8. What are the reasons and the procedures used to justify design modifications, or even a change to a different design concept? Based on what data? What are the lessons learnt from organizations that have already conducted such an iterative process? (3/3)

Lessons learnt from organizations

- Inflexibility/inertia may occur if design is defined in too much detail (science + PA ⇔ design)
- Stakeholder views and changes in regulations, program strategy and site characterization may lead to changes in design
- Level of design details required for PA is less than for engineering
- Importance of FEP's may evolve (PA, science, perception)
- Insufficiently realistic design assumptions & oversimplified design concepts may lead to the need to re-design at a later stage (e.g. early failure, concrete liner, ..)
- Well-defined demonstration tests (of implementation at large scale) at an early stage are important
- Requirements other than LT safety have to be considered in an early stage of the program (this is not the case in some programs)
- Design lay-out as you go in response to real site conditions
- Integration (science, PA, engineering) at an early stage is essential

9. How are the consequences of design changes incorporated back into SA ?

- Obviously by updating models
- Important design changes may modify FEP's screening and may lead to changes in SA models or scenarios
- Consequences should be recorded in direct comparison between designs
- Guidance for new R&D
- Full or focused SA should be performed as appropriate