Initial Review Phase for SKB's Safety Assessment SR-Site: FEP Handling

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Objectives

- Review SKB's FEP handling methodology
  - Check that the approach is defensible
  - Check that the approach is systematic
- Undertake FEP spot-checks
  - Check for consistency, sufficiency, traceability and transparency of information in SKB's FEP Database and associated documentation

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Approach

- Material reviewed:
  - SKB's FEP Database
  - FEP Handling in the SR-Site Main Report (TR-11-01)
  - The FEP Report (TR-10-45)
  - QA instructions the FEP database and processes descriptions
  - Process reports and supporting reports

SKB's FEP Management Process 1/2

- Steps in SKB's FEP analysis:
  - SKB developed interaction matrices for the buffer, near-field and far-field of a spent fuel repository in the 1990s using the Rock Engineering System (RES)
  - Processes, variables and process diagrams were derived from the interaction matrices and these were first presented in the SR 97 safety assessment
  - The SR 97 work provided the foundation for the development of the first SKB FEP Database and the process reports that were presented as part of the SR-Can safety assessment
  - The SR-Can FEP Database and reports provided the basis of the SR-Site FEP Database and process reports

SKB's FEP Management Process 2/2

- Confidence building:
  - Use of subject experts from SKB and its contractors to develop and check process descriptions according to instructions
  - Use of a systematic methodology for identifying FEPs
  - Audits against Project FEPs in the NEA International FEP Database
  - Checks against original interaction matrices

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FEP Management Issues 1/4

- FEP categories:
  - It is confusing that the reference initial state FEPs are called variables and deviations from the reference initial state are called initial state FEPs
- FEP catalogue in the FEP database:
  - FEP descriptions and entries on FEP handling in the FEP database are often very brief and a full understanding of the treatment of FEPs in the safety assessment can only be achieved by consulting the supporting documents
  - Typically FEP databases include more complete FEP definitions and discussions of FEP screening and treatment, or may include hyperlinks to relevant report sections

FEP Management Issues 2/4

- Process diagrams and influence tables:
  - Process diagrams show couplings between processes and variables, and influence tables describe the couplings and how they are treated, but these are not available for all FEPs
- Assessment Model Flow charts and tables:
  - AMF Charts and Tables include links to codes used to assess different processes, but there are inconsistencies with the codes used in the safety assessment

FEP Management Issues 3/4

- FEP audits:
  - Project FEP lists in NEA Database were developed 10 to 20 years ago and there is no demonstrable awareness of any more recent developments in approaches to FEP analysis
  - The fields for recording whether mappings have been checked have not been completed for initial state FEPs
  - Almost all recording, checking and revision of FEPs is dated December 2010 with most checks and revisions done by one person
  - Some NEA project FEPs have been excluded, although they appear to be relevant, but this has not led to any gaps in the FEP catalogue

FEP Management Issues 4/4

- FEP mapping to SR 97 interaction matrices:
  - There are incomplete entries, missing references, incomplete QA records, unmapped FEPs, cursory entries
  - However, the purpose of the mapping is unclear and its incompleteness does not appear significant to the quality of the safety assessment
- QA instructions:
  - There appear to be no QA instructions for the documentation and review of biosphere processes

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Main Findings on SKB's FEP Methodology

- Systematic and defensible approach with appropriate QA procedures and checks on comprehensiveness
- FEP database entries are typically very brief compared to most other project FEP databases and understanding requires consultation of supporting documents
- There are minor information gaps in the FEP database
- Not all entries and confirmations of QA checks are complete

Example FEP Spot Checks

- Check FEP definition, handling description, referencing and mapping to NEA FEPs in the FEP database
- Check FEP discussion in process report and supporting reports
- Examples:
  - F03 Induced fission (criticality)
  - Oth01 Meteorite impact
  - C11 Corrosion of copper canister
  - Bu07 Piping/erosion

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F03 Induced fission (criticality)

- FEP Catalogue gives summary screening decision with references to SR-Site Main Report, the Fuel and Canister Process Report and links to NEA Project FEPs
- The Fuel and Canister Process report summarises arguments for failed canister with reference to an unpublished report (now published)
- Cites earlier work in support of the view that the probability of criticality outside a canister is negligibly small
- The safety assessment addresses the FEP but doesn't provide adequate discussion of the arguments that support the view that criticality as a results of fuel degradation in a failed canister followed by relocation and accumulation of plutonium at different locations in the repository is unlikely

Oth01 Meteorite impact

- FEP Catalogue gives summary screening decision with no reference to supporting discussion or arguments
- Justification for excluding the effects of meteorite impact found in the FEP report

C11 Corrosion of copper canister 1/3

- Corrosion processes considered in Fuel and Canister Process report:
  - Corrosion by oxygen (atmospheric, in buffer, in backfill, in groundwater, in glacial melt water)
    - Pitting corrosion and localised corrosion caused by uneven gap closure
  - Corrosion by radiolysis products
    - Nitric acid from gamma radiolysis of moist air and oxidants from water radiolysis
  - Corrosion by dissolved sulphides
    - From buffer, groundwater, microbially generated (including biofilms)
  - Corrosion stimulated by impact damage
  - Corrosion by chloride
  - Corrosion in water
  - Corrosion by sulphate

C11 Corrosion of copper canister 2/3

- Consistent with corrosion processes described in the NEA FEP Database, except corrosion in water not in NEA FEP Database
- Treatment of corrosion processes:
  - Discussed and concluded to be insignificant, drawing on supporting analyses and experiments
  - Corrosion rate evaluated using an analytical model in Excel

C11 Corrosion of copper canister 3/3

- Some processes dismissed but not discussed in detail:
  - Effects of temperature on corrosion, although temperature effects have been neglected because corrosion model is based on transport control and mass balance
  - Corrosion stimulated by impact damage (discussion is unclear)
  - Healing of corrosion pits
  - The effects of expansion of copper corrosion products on canister and buffer
  - Corrosion caused by fission products (halogens)
  - Changes in groundwater chemistry caused by construction

Bu07 Piping/erosion

- Processes considered
  - High water flow through fractures causes piping through swelling bentonite
  - Erosion of clay particles if drag forces large enough
  - Causes loss of buffer density
- Consistent with mapped processes described in the NEA FEP Database

Bu07 Piping/erosion

- Treatment in safety assessment
  - Preliminary model to estimate maximum piping for a given flow
  - If piping too great would abandon deposition hole
  - Swelling may close pipe
  - Process expected to stop after water saturation and homogenisation of bentonite
  - Uncertainties are large and tests are on-going
  - Relevant during installation and saturation period
  - Neglected for other periods, but this assumes the process stops, which is questionable

Summary of FEP Spot Checks

- FEP treatment generally traceable through FEP Database and cited SR-Site reports
- Project FEPs in NEA FEP database generally addressed by FEPs in SKB's database
- Many FEPs expected to be unimportant often eliminated with limited or no supporting analysis
- No major issues identified in the definition, handling description, referencing and mapping of FEPs to NEA FEPs

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