Fuel data needs for Posiva's post-closure safety case

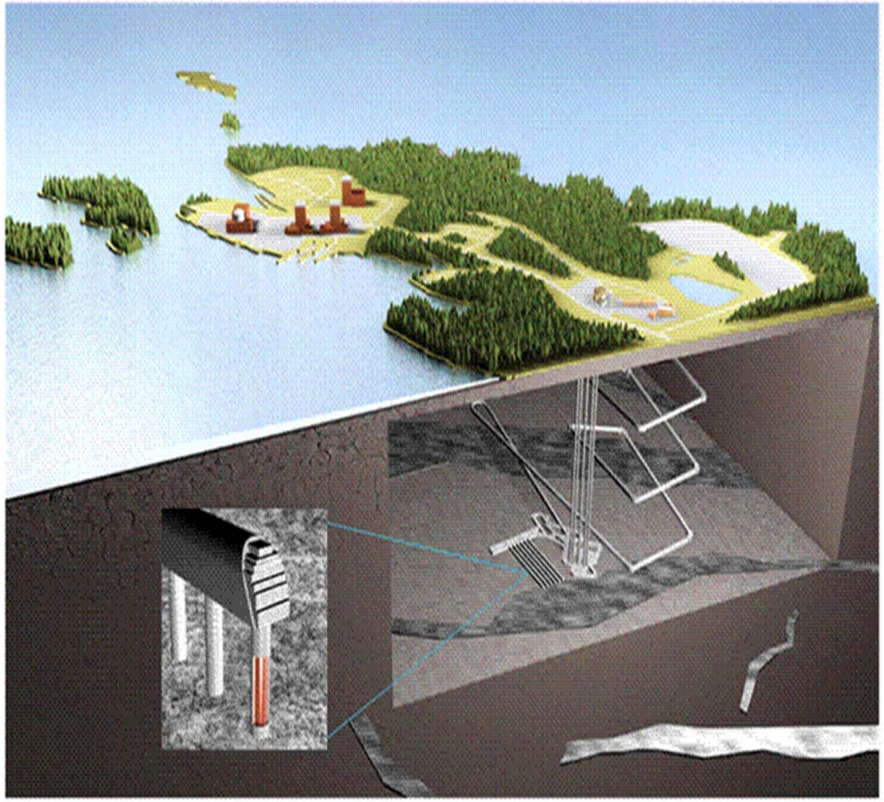
B. Pastina (Posiva)

IGD-TP 5th Exchange Forum

Kalmar 28-29.10.2014

POSIVA

Disposal system at Olkiluoto, Finland



…now preparing the new safety case (TURVA-2020) for the operational license application

TURVA-2012
Safety case report portfolio

SYNTHESIS

- Design Basis
- Description of the Disposal System
- Features, Events and Processes
- Performance Assessment
- Formulation of Radionuclide Release Scenarios
- Models & Data reports
- Assessment of Radionuclide Release Scenarios for the Repository System & Biosphere Assessment
- **Complementary Considerations**

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Key reports of the safety case

- **Performance assessment**
  - most likely evolution over 1M years
  - the barriers perform as designed
    - i.e. they meet the design requirements
    - e.g. sub-criticality over 1M years
  - the effect of uncertainties are analysed in these reports →
- **Formulation of scenarios**
  - i.e. what can go wrong?
- **Assessment of scenarios**
  - i.e. how bad does it get?
  - radionuclide release and transport model
  - dose assessment

Fuel properties that matter…

- For the whole safety case
  - Spent fuel type and overall inventory (tU)
  - Decay heat limits on the canister
- For the performance assessment
  - ensure the fulfillment of the requirements set on the fuel/canister e.g.
  - waste acceptance criteria
    - fuel type and amounts
    - decay heat
  - criticality safety-related requirements
  - safeguards-related requirements

Fuel data that affect criticality safety

- Radionuclide inventory & evolution with time
  - inventory of fissile radionuclides
  - inventory of burnup credit-related radionuclides
    - Only U-235 and U-238
    - Actinide-only
    - Actinides + FPs
    - U-235, U-238 + FPs
    - U-235, U-238 + rare earths (Sm, Gd, Nd etc)
  - need to account for the long times and the stability of the elements in the fuel matrix
- Geometry & materials evolution with time
  - presence of water and other moderators, neutron reflectors…

Increased need for isotopic codes validation

In case long-term criticality cannot be excluded…

- Models and data are needed to evaluate the potential consequences of a criticality event in disposal conditions
- (restricted access?) Codes for criticality event consequence evaluations are needed
  - rapid transient scenario consequences
  - quasi steady-state scenario consequences
- The output would be **≠ source term(s)** for long-term criticality scenario formulation and assessment
- Spatial distribution of fission & activation products?
- Temperature distributions?

Fuel properties that matter…

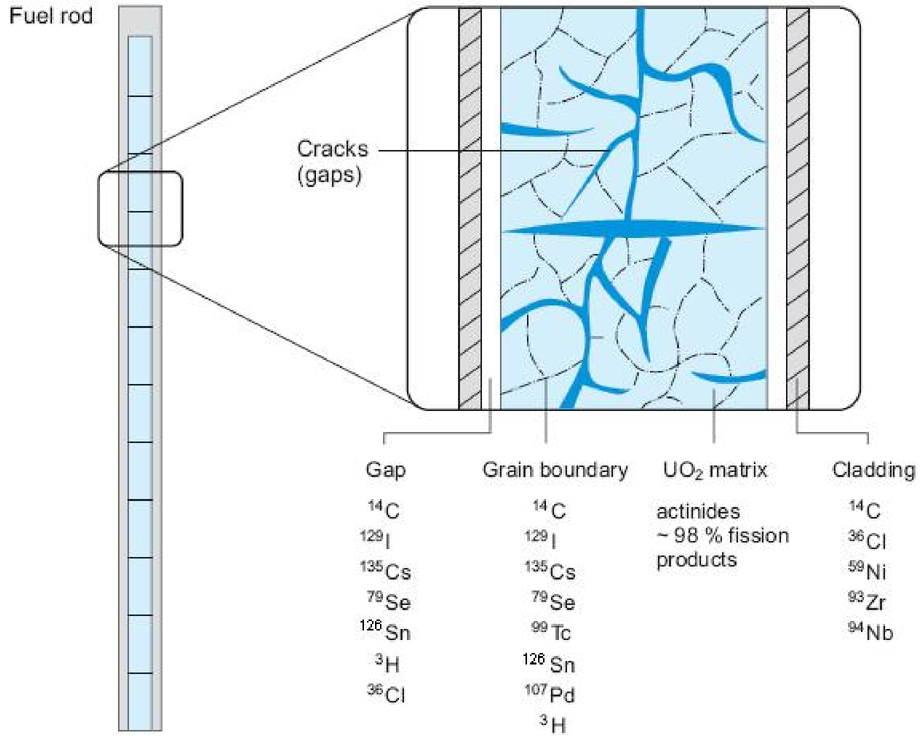
- For the whole safety case
  - Spent fuel type and overall inventory (tU)
  - Decay heat limits on the canister
- For the performance assessment
  - Fulfilment of requirements
- For the formulation and assessment of scenarios
  - Data to compile the source term for the radionuclide release and transport model
    - Radionuclide (RN) inventory
    - Partitioning of RNs within the fuel assembly
    - RN release properties of the various parts of the fuel assembly

Fuel data for the source term (1/4)

- Data that affect the radionuclide inventory at the time of disposal
  - geometry of fuel and of the fuel in the core
  - U-235 initial enrichment
  - irradiation history, e.g.:
    - linear heat generation rate
    - average assembly burnup at discharge
    - (void history for BWR, use of control rods for PWR, UO_2 density…)
  - cooling time before encapsulation
  - fission gas release to estimate the labile fraction of RNs
  - impurities (N, Cl) in the UO_2 matrix, cladding and other metal parts
    - they affect the C-14 and Cl-36 inventory calculations

Fuel data for the source term (2/4)

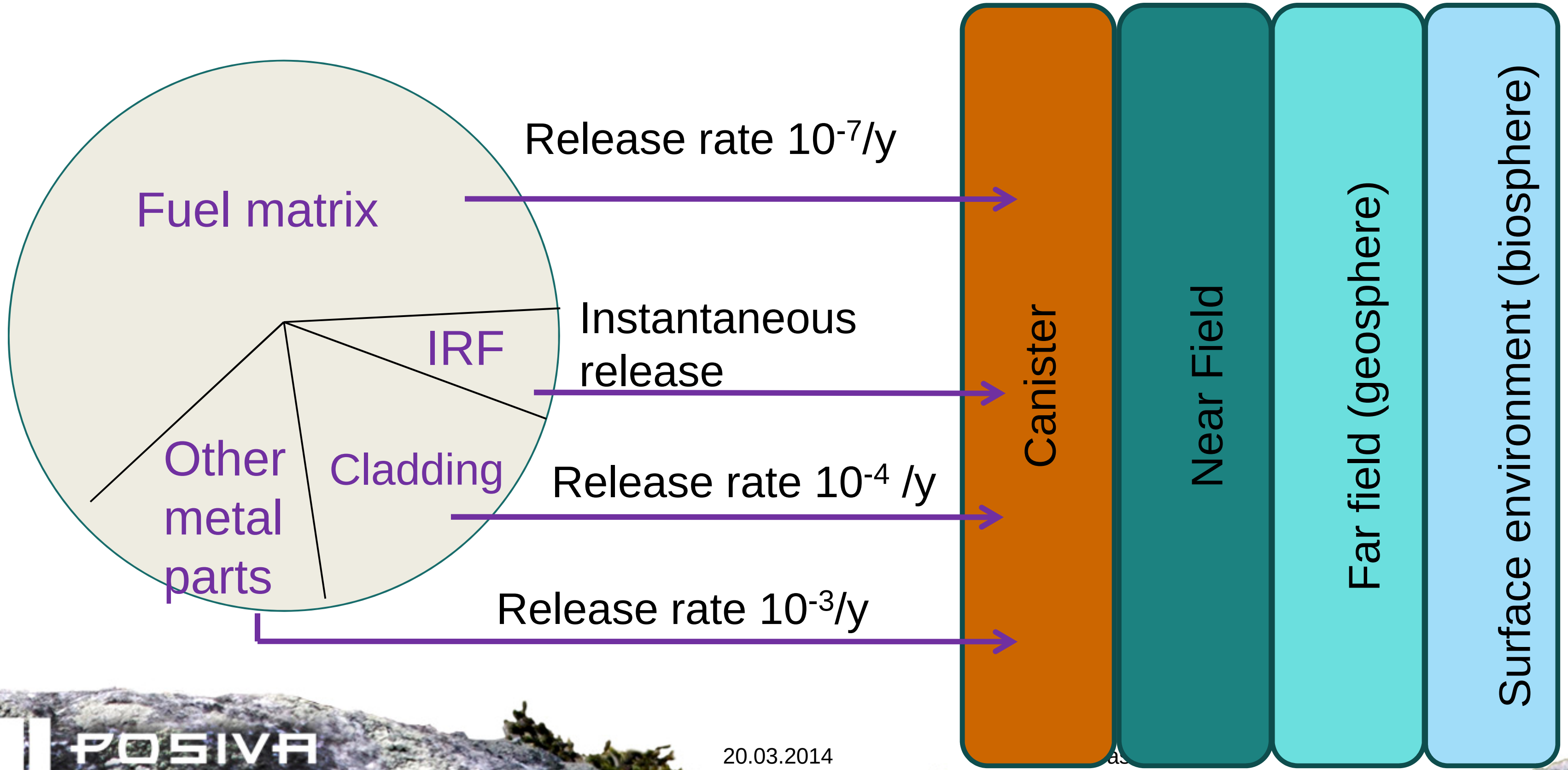
- The radionuclides (RN) are distributed among 4 compartments:
  - Gaps, cracks, grain boundaries (labile fraction or IRF)
  - UO_2 matrix
  - Cladding
  - Other metal parts in the fuel



Johnson & Tait 1997

Fuel data for the source term (3/4)

- Data that affect RN release rates
  - fuel types (UO_2, MOX, vitrified matrix)
  - dissolution/corrosion rates in disposal conditions
  - thickness of the cladding/other metal parts



Fuel data for the source term (4/4)

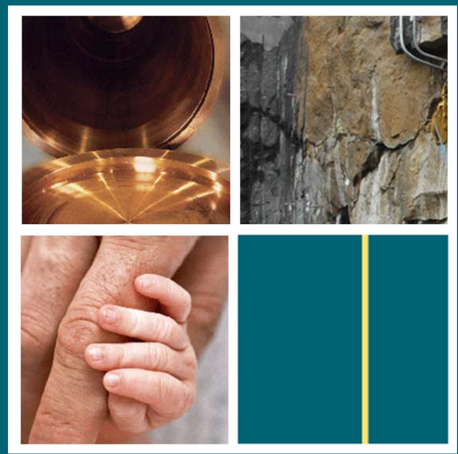
- Additional source terms inside the canister?
- e.g.
  - control rod assemblies
    - materials, inventories, release properties?
  - presence of leaking or damaged fuel rods
    - partially oxidised UO_2 has different release rates
  - presence of crud
    - amount, composition
    - RN inventory
    - release rates

Bottom line…

- If a new fuel design or a new reactor type is considered, data are needed to assess…
- **criticality safety**
  - e.g. models, data and codes for criticality safety analyses and consequence evaluation, if needed
- **radionuclide release properties** of the new waste stream in repository conditions
  - fuel with chemical additives (e.g. Cr and Al)
  - fuel with burnable poisons (Gd_2O_3)
  - new cladding or structural materials
  - fuel design enhancements
    - e.g. liner at pellet/cladding
  - leaking fuel rods
    - i.e. extent of oxidation of UO_2 pellets, cohesion of UO_2 matrix

Feedback to the information exchange platform with SNTP

- There is a need for cooperation between the nuclear fuel community and the radioactive waste management community
- Consider the whole life cycle of the fuel to evaluate the impact of potential fuel/reactor design changes
- There is also a need to develop together methods to verify the fulfillment of the requirements set on the fuel, e.g.
  - waste acceptance criteria
    - incl. decay heat
  - criticality safety-related requirements
  - safeguards-related requirements



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