Characterisation lessons learned from Finland

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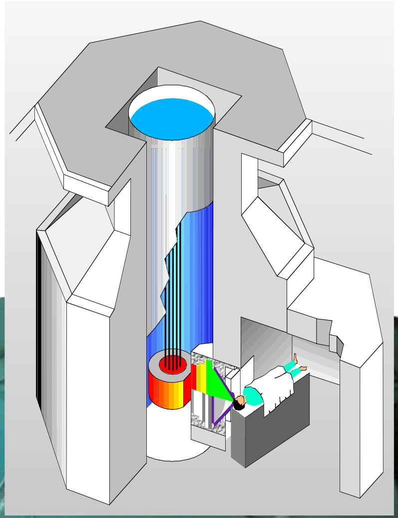
Overview of the sites

Overview of the sites – laboratory and hot cells (OK3)

- History of the old laboratory and hot cell facilities
  - 2nd floor
    - Radiochemistry
    - Wide spectrum of radionuclides with low activities
    - Almost empty
  - 1st floor and cellar
    - Material research, mechanical testing
    - Mainly activated steel studies (RPV, Co-60) with high activities
    - Hot cell, cutting (EDM), specimen storage
    - Paint decontamination studies with high Co-60 and Cs-137 activities
    - Cellar used as a storage and waste dump
- Move to new facilities (Centre for Nuclear Safety) in 2016
  - Not all waste, some useful materials/equipment left behind

Overview of the sites – FiR1 research reactor (FiR1)

- General Atomic's TRIGA Mark II type
  - First reactor in Finland
  - Initial power of 100kW in 1962, raised to 250 kW in 1967
- Operation (1962-2015)
  - Intensive neutron beam research, activation analysis, irradiation testing, isotope production
  - Facility for Neutron Capture Therapy constructed in mid 1990's
  - Special materials to be managed in decommissioning
- Dismantling will start in spring 2023



Characterisation needs and capability building

OK3: Characterisation needs and capability building

- Main challenge with hot cell laboratories
  - Task force
  - Large volume of movable goods, mostly waste
  - Lack of information
    - What is important? What is dangerous? What is waste?
  - Possible unknown radionuclides
  - Distributed contamination, high activity spots possible
  - Decades of working not according to **current** radiation safety culture principles
  - Lack of information due to retirements and changes in personnel


OK3: Characterisation needs and capability building

- Main challenges
  - Formation of scaling factor
  - Some legacy waste
  - Specimen storage
    - Return to owner
    - EU projects? USSR? DDR?
  - Surprises
    - Alpha contamination in the clean room
    - Gaseous RN in “empty”-marked container
    - Nuclear materials outside of bookkeeping
      - pellets of natural uranium
      - uranium -and thorium ore samples
      - depleted uranium (150 kg) used as radiation shielding
    - Active samples stored without markings
      - e.g. a GBq-level active sample in a lead container was “hidden” in a corner of storage room

Legacy waste of several GBq of Cs-137

OK3: Characterisation needs and capability building

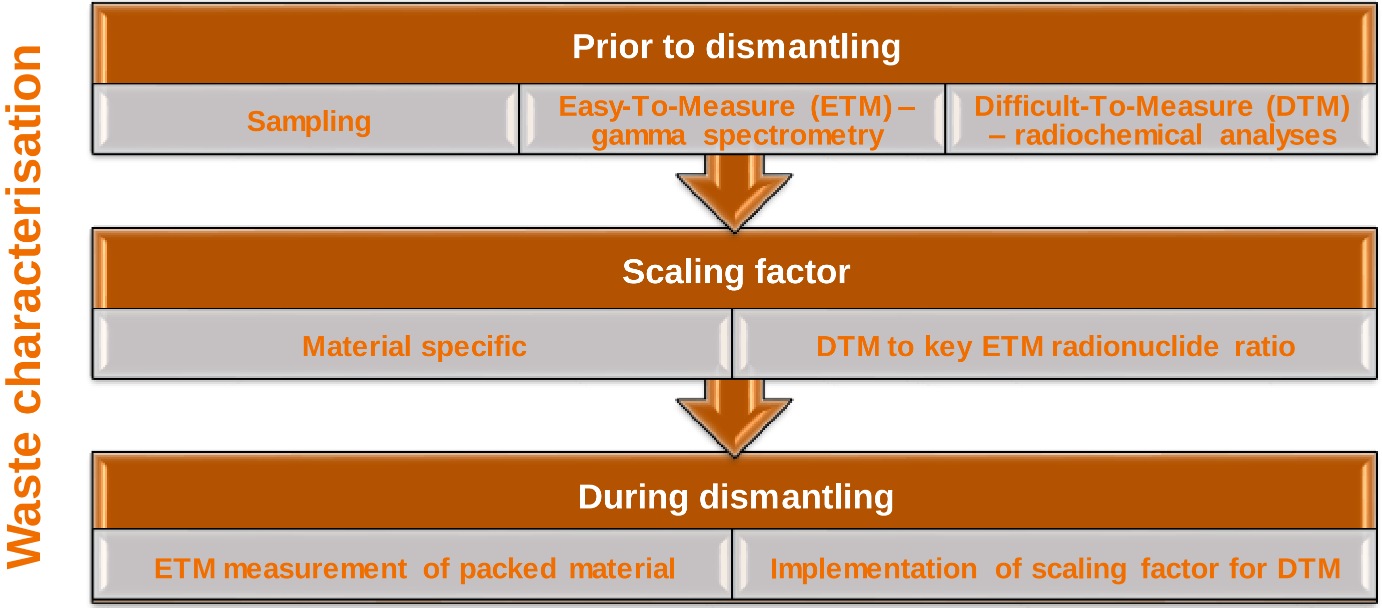
- Solutions
  - Discussions with former/retired personnel
  - Ad hoc solutions for surprises
  - Scanning of all objects with hand held equipment
  - Decontamination with industrial washing machine
  - Free release measured in tool monitor prior to packing into waste containers (200 l drums) for ISOCS measurements
- Results
  - Production of secondary waste
    - Waste water treated with NURES
  - Large volume of free released waste

NURES

Alpha contamination
Clean-up gear

FIR1: Characterisation needs and capability building

- Mainly activation
- Limited contamination



FIR1: Characterisation needs and capability building

Data survey

- Operation history
- Chemical composition
- Construction drawings

Completion of missing information

- Chemical composition
- Accuracy of original blue prints
- Conservative assumptions for missing data

Activation calculations

- Neutron transport calculations
- Activation calculations
- Possible separate models for different operation periods (i.e., power, structural changes e.g. plugging of the beam ports)

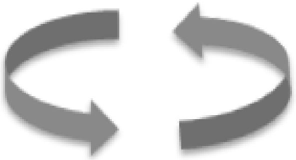
Sampling

- Samples from activated materials
- Nuclear-wise activities in each material
- Iteration of data for dismantling and waste management plans

Dismantling and waste management plans

- Selection of appropriate dismantling method i.e., drilling or wire saw
- Logistics
- Dose estimates
- Contamination control
- Packages and their compatibility for the waste final disposal site

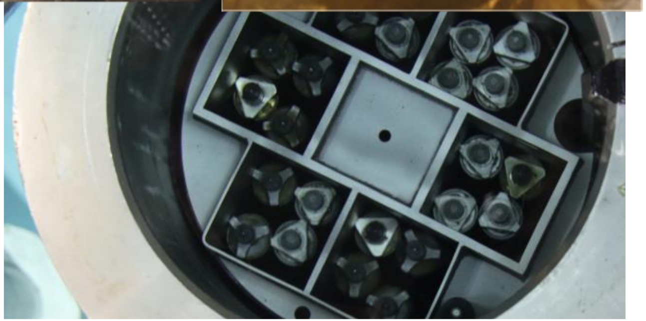
Activation calculations



Measurements

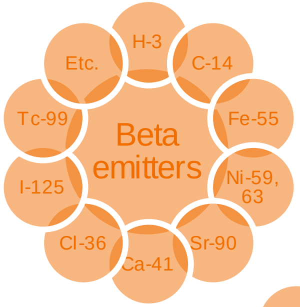
FIR1: Characterisation needs and capability building

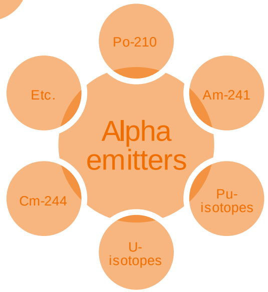
- Main challenges in project progress related to characterisation
  - Spent fuel in reactor
  - Sampling and accessibility
  - Lacking documentation
    - Sometimes even old unknown components/devices
  - Waste Acceptance Criteria
- Solutions
  - Going forward with the known information
- Results
  - Conservative assumption may result in overconservative waste volumes
  - Incomplete data may require updating on later phase of a projects
  - NDE calculation provides a basis for preliminary planning, but need to be validated with measurements.



FIR1: Characterisation needs and capability building

- Main challenges in activation calculations
  - Wide variety of materials
    - Different types of e.g. steel
  - Wide variety of radionuclides
  - Chemical composition
    - Even well specified materials may not mention all impurities in their specifications
  - Complicated operation history
- Solutions
  - Material standards, references in literature
  - Sampling of inactive or already dismantled materials
    - More sampling after spent fuel removal
  - Elemental analysis of wide range of materials
  - Conservative assumptions on composition, operating history and fluxes
- Results
  - 15 scaling factors prior to decommissioning
  - Scaling factors to be updated if needed during decommissioning

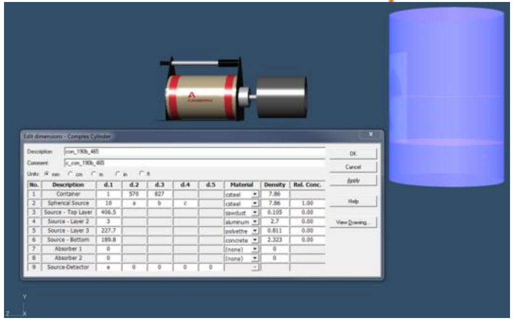




FIR1: Characterisation needs and capability building

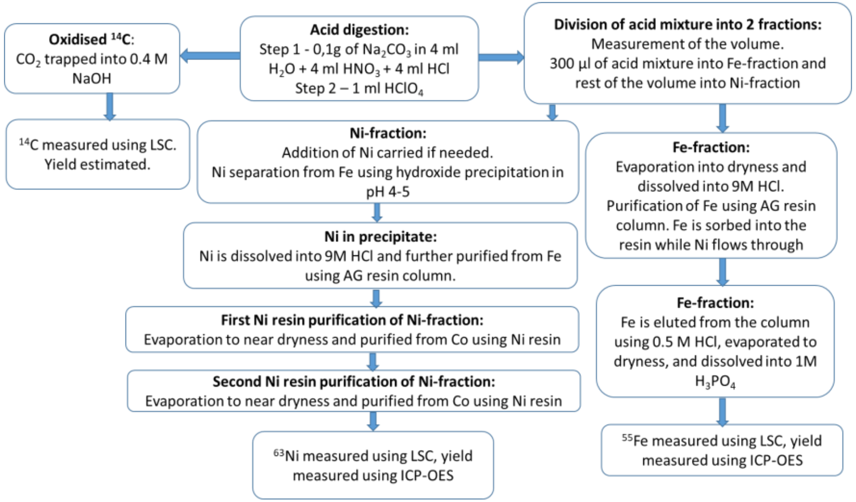
- Main challenges in ETM measurements
  - In general well established
  - Uncertainties in heterogenous waste
  - Compliance with WAC and free release
- Solutions
  - Validation and verification of ISOCS
    - Geometries, sensitivity, background
  - Minimise uncertainties in waste packages (activity and material)
  - Optimise background radiation
- Results
  - Validation and verification (V&V) assessment report
  - Different devices and locations (active waste and free release)

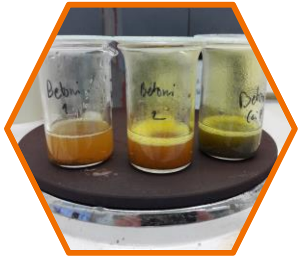
ISOCS set up

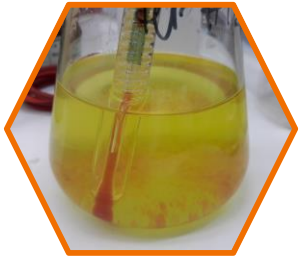


FIR1: Characterisation needs and capability building

- Main challenges in DTM measurements
  - Long radioanalytical procedures
  - Volatility of C-14 and H-3 during sampling
  - Method validation
  - How much resources should be used for measurement of low level DTMs?
- Solutions
  - Method validation via intercomparison exercises (ISO 13528:2015)
  - Capture of volatile DTM during sampling
  - Discussion on significance of the DTM
- Results
  - List of material wise relevant DTMs
  - Validated methods, confidence in results





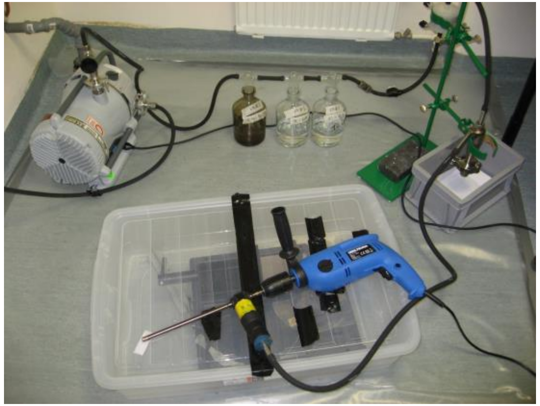


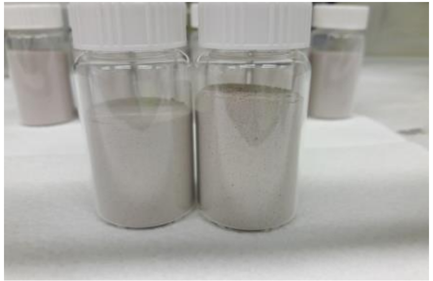
Example of innovations

Volatility of DTM during sampling

- FiR1 sampling technique development – 1st generation
  - Volatility of H-3 and C-14 during drilling of activated concrete core
  - Drilling configuration
    - Hollow drill bit – fine powder sample
    - Air and drilled powder collected into a cyclone via suction
    - Contamination control
    - Released DTMs collected in absorption bottles

35 % of H-3 evaporated during sampling



Conclusions

Conclusions

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- Lessons learnt from OK3 decommissioning project
  - Lack of information made the work progress sometimes very slowly
  - Although the vast majority of activity consist of Co-60 and Cs-137, some other radionuclides were also present (e.g. impurities in pressure vessel steel and other reactor internals). Also some ”rare” nuclides, e.g. Kr-85 were found
  - Industrial washing machine has been operated for around 1400 cycles so far. It has been a very effective and fast way to remove surface contamination from the washable items
  - The work itself was sometimes quite hard and unpleasant and thus it was sometimes hard to find ”voluntary workers” to do the work in addition to their other work → support from the management is important.

Conclusions

- Lessons learnt from FIR1 decommissioning project
  - Establishment of WAC early
    - Waste amount estimations
    - Calculations
    - Nuclide and scaling factors
    - Measurements
  - Material reserve and detailed specifications
  - Multifaceted capabilities needed
    - In-house capability building takes years
  - Knowledge management
    - History
    - Access to information

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