ESTABLISHING DECOMMISSIONING PLANS, MANAGING THE TRANSITION PERIOD BETWEEN OPERATION AND DECOMMISSIONING, AND THE DECOMMISSIONING OF THE POOL REACTOR THETIS IN GHENT, BELGIUM
Summary

- The Thetis Decommissioning Project (*U Ghent / Bel V presentation*)
  - History
  - Licensing procedure for decommissioning
  - Content of demand for license for decommissioning and dismantling
  - License to start decommissioning
  - The removal, transportation, final treatment and conditioning of the research reactor spent fuel of the University of Ghent achieved in 2010
  - The question for a solution for the spent fuel
  - On-site operations
  - Transition period between removal of spent fuel and start of decommissioning phase (09/2010 – 01/2013)
  - Final decommissioning phase (2013 - 2015)
  - Situation 2015
Thetis research reactor:

Type: Pool type.

Fuel: Low enriched Uranium.

Moderator: Light water.

Reflector: Graphite
Building Thetis reactor 1965-1967

Fig. 1: Vertical cut of reactor pool and core
1967: Commissioned.

Power: 15 kW
1972: core enlargement.

Power:
150 kW nominal,
250 kW maximum.
Mainly used as a neutron source for:
- Production of radionuclides for material analysis
- Activation analysis.
Licensing procedure for decommissioning

- Based on requirements of FANC
- Based on:
  - IAEA Safety Requirements: Predisposal Management of Radioactive Waste, including Decommissioning (WS-R-2)
  - IAEA Safety Guides:
    - Decommissioning of Nuclear Power Plants and Research Reactors (WS-G-2.1)
    - Decommissioning of Medical, Industrial and Research Facilities (WS-G-2.2)
    - Decommissioning of Nuclear Fuel Cycle Facilities (WS-G-2.4)
Content of demand for license for decommissioning and dismantling

- Introduction
- Description of the installation
- Radiological and toxic inventory
- Dismantling strategy
- Purpose, dismantling alternatives, safety principals and criteria, destination of the site, …
- Project Management
- Personnel, Documentation, Financing
- Quality System
Content of demand for decommissioning and dismantling

- **Dismantling activities**
  - Planning, decontamination and dismantling techniques, release, re-use of materials,…
  - Safety Analysis
  - ALARA study
  - Safety systems, Incident Analysis, Criticality, Industrial Safety, Emergency Planning, Security,…
  - Environmental Report
License to start decommissioning

- Safety document “Decommissioning of Thetis Reactor” needed
  - Approved by FANC and Bel V
  - All safety related modifications during decommissioning had to be approved

- Reporting to FANC and Bel V

- 3-monthly internal inspections during cooling period
  - ventilation, pneumatic pumps, demineralisation loop, reactor pool, control room, safety systems, radiation monitoring, underpressure, alarms, reactor water activity, reactor water temperature, water level.

- Monthly Bel V inspections during cooling period
The removal, transportation, final treatment and conditioning of the research reactor spent fuel of the University of Ghent achieved in 2010 (under the existing license for operation of the reactor)
The quest for a solution for the spent fuel.
Thetis core: 20 elements, typically containing 25 fuel rods.

Total number of:
- elements irradiated: 25,
- elements present: 26,
- rods: 583,
- $^{235}\text{U}$: 3758g
Fuel rod:
- Active pin height: 376 mm
- Containing 5% enriched Uranium oxide,
- Graphite plugs 162 mm at both ends.
- Cladded with 200 \( \mu \)m AISI304L stainless steel
- Average burn-up: 3.15 GWd/tIHM,
- Maximum burn-up: 5.15 GWd/tIHM
Possible solutions

1) Reprocessing.

2) Intermediate storage awaiting final disposal

Criteria for evaluation:
available techniques, safety, waste production, total cost

Fuel = exotic (no end user).
Acceptance criteria not met due to graphite plugs.
Technical issues: cutting, repackaging, reprocessing, final storage.
Total cost = high.
Option abandoned

New technique:
- Direct cementation in 400 l drum with inner basket.
- Interim storage.
Technically feasible.
Total cost = lower.
Option adopted

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straling@ugent.be
On-site operations.
Unloading of reactor Thetis in 2010
Sipping test

Element placed in sipping tube, Tube hoisted to the surface, 2h delay (sipping), Water pumped in tube (15 min).
Sipping test measurement

Gamma spectrometry using Germanium detector

Water sample

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Moving element to presentation position:
- Visual inspection
- Identification
Positioning transfer container to pick up element from presentation position
Loading element in transfer container.

Dripping (1h).

Drying: overnight in dry storage.
Loading transport container.
Docking of transfer container.
Doserate measurement during element shift.
Sealing transport container.
Drying container.
Leaktest.
Getting ready for transport
Documents per element:
- Quality assurance check list for manipulations
- Leak test and identification
- Dose rate measurements.
- Container certificates
- Transport documents (ADR adherence)
Transport under “special arrangement”
Enhanced security on site and during transport
Conditioning of the spent fuel:

• Cut top and bottom plugs from each element.
• Conditioning in 400 l drum.
• Internal basket containing 4 concentric cylinders for fuel elements.
• Additional central cylinder for cut plugs.
• Use of special cement mixture containing LiNO3 due to presence of Aluminium.
• Criticality.
Cutting at Belgoprocess
The unloading of the Thetis fuel was completed during the summer of 2010.

The cumulative dose for the team at Thetis was only 404 μSv.

7 400 l drums of conditioned fuel were produced and stored at Belgoprocess.
Transition period between removal of spent fuel and start of decommissioning phase (09/2010 – 17/03/2013)

- 3-monthly internal inspections during transition period
  - ventilation, radiation monitoring, underpressure, alarms, water level, reactor water activity, reactor water temperature.

- 3-monthly Bel V inspections during transition period
  (Bel V organised 3 thematic inspections on Fire Safety between 2011 and 2013)
Transition period between removal of spent fuel and start of decommissioning phase (09/2010 – 17/03/2013)

- Decommissioning license (15/05/2012)
  - License conditions
    - Specific procedures needed (release of waste, dismantling techniques, …)
    - Safety evaluation report / Decommissioning plan / Technical report
    - QS system
    - Working procedures and instructions / ALARA study
    - Inventory of radioactive waste
    - Inspection program of safety systems (3-monthly)
    - Risk analysis (for new dismantling techniques)
    - Dose registration
    - Operational experience feedback system
    - Methodology and results of final characterisation
Final decommissioning phase (2013-2015)

- Started on March 18, 2013

- Different phases
  - Primary mapping (ended)
  - Asbestos removal (part 1) (ended)
  - Dismantling of instrumentation / rabbitsystem / internal reactorparts (graphite, grid, core plate) (ended)
  - Dismantling of watercircuits and ventilation system, stripping of contaminated installations (ended)
  - Decontamination of infrastructure (ended)
  - Asbestos removal (part 2) (ended)
  - Removal of activated bottom plate of reactor pool (ended)
  - Final radiological survey (ended in 2015)
    - Declassification to Class II (or III) (foreseen before the end of 2015)

- Bel V inspections (monthly)

- UGhent / SCK / Belgoprocess / Bel V meetings during decommissioning phase (2 weekly)
Final decommissioning phase (2013)

- Approval by Bel V of all reports and procedures in February 2013
- Received doses from 18/03/2013 (start of decommissioning phase) till 06/08/2013 (after removal of most of the radioactive waste)
  - 1561 man.µSv in total (61 persons)
  - 232 µSv (max. individual dose)
Final decommissioning phase (2013)

- **1 incident** rated INES 1 in April 2013: no underpressure in controlled areas due to power outage. No radiological consequences.

- **Unforeseen activation** of the bottom plate of the reactor pool (detected during decommissioning phase → removal of liner in May 2014 and characterisation of activated bottom plate (Co-60 and Eu-152) in June 2014

  Approval of Procedures & Methodology by Bel V was needed.
Reactor building
Entering Top Tec cutting device
Waste Management
Cutting of instrumentation tubes
Removal of the grids
Removal of the graphite blocks
Storage of graphite blocks in 1m³ containers
Removal of supporting structure
Cutting of supporting structure
Sawing
Local ventilation
Ventilation unit
Pumping of the reactor pool water
Mapping and decontamination of the pool
Rabbit station (1)
Rabbit station (2)
Laboratory
Transportation
Waste Management Program

- All materials are selectively collected in waste categories
- Specific waste drums are used to collect the waste
- All drums are radiologically characterised
- The results of the characterisation determine the removal paths of the material
- All information of each drum is saved in a data management system
Measuring methods for 60Co activity

- Low Level Radioactive Waste System (LLRWS)
  a fixed laboratory setup manufactured by Canberra and VUB (lead shielding) High-Purity Detector (relative efficiency of 25%)
Measuring methods for $^{60}$Co activity

- **ISOCS** (In Situ Object Counting System)
- Mobile system
- Used in a fixed setup
- Used for measurement of walls & floors of the reactor-building
- Manufactured by Canberra
- **Genie-2000 software** (Canberra)
- High-Purity Ge-detector
  (relative efficiency of 25%)
Measurement Zone
Measurement Zone
Waste storage
Situation 2015

- Activated bottom plate
  - Approximately 3,1 MBq Eu-152
  - Approximately 0,34 MBq Co-60

- Declassification to Class II (or III) foreseen before the end of 2015

- Measurements for free release of reactorbuilding performed in 2015 (1 contamination detected by Bel V in a former lab → was removed in June 2015)

- Removal of waste drums still ongoing (free release, NIRAS and melting at Studsvik)
Activated bottom plate
Inspection hole
Cover
Detected contamination in former lab
THANKS to

- University of Ghent
- SCK
- Belgoprocess
THANK YOU for your attention!

ANY QUESTIONS?