Decommissioning of Nuclear Facilities in Switzerland – Lessons learned
International Conference on Nuclear Decommissioning, Aachen/DE, November 27 – 30, 2017
Overview

material sciences
radio chemistry
radio pharmacy
solar concentrator
nanotechnology
donlab
biology
energy research
 PSI west
particle physics
proton accelerator
muon source
proton therapy
synchrotron light source
neutron source
PSI east
SwissFEL
Nuclear installations on the PSI area

- (ZWILAG)
- AERA with VVA*
- Hotlabor
- DIORIT*
- SAPHIR*
- PROTEUS*

*Post-operation phase/Decomm./Dismantling
First reactor in Switzerland; used for isotope production, reactor training, neutron source for various experiments

1955 USA exposed a reactor at the “Atoms for Peace” conference in Geneva

1956 Laying of the cornerstone in Würenlingen

1957 First criticality

1960 Approval by Swiss government

1985 Approval for 10 MW

1993 Final shutdown

2000 Decommissioning ordinance

2008 Dismantling of the pool completed

2015 Cleanout of the KBL (“Kernbrennstofflager”)
ENSI-Inspection at 7. of April, 2016
Proprietary Swiss development. Goal was the construction of industrial applicable reactors for material testings and experiments.

1960 Operation with natural uranium and D₂O as coolant and moderator.

1966 Uprating from 20 MW to 30 MW.

1972 (after modification): Operation with LEU.

1977 Final shutdown.


1994 Approval of dismantling the reactor.

2005 Asbestos was found → interruption until 2009.

2013 Dismantling of biological shielding

2016 Cutting of the „Arbeitsboden“ (22 t activated Fe)

2019 (?) 2. Decommissioning ordinance for greenfield
Biol. Shielding DIORIT: 2012

March 2012

September 2012
Zero power reactor for different experiments with various fuel arrangements (U, MOX).

GCFR: gas-cooled fast reactor
HCLWR: tight-pitch, high conversion, light water reactor
HTR: modular high temperature reactor
HPLWR: high performance light water reactor fuel
2011 Final shutdown
2012 Removal of fuel
2013 Application for decommissioning
2015 Approval of post-operation phase, deactivation of reactor instrumentation.
2016 Public obligation of the project. No objection.
2017 (?) Decommissioning ordinance
Test incineration facility (VVA)

Part of the waste management facilities, „Anlagen zur Entsorgung radioaktiver Abfälle“ (AERA)

1974 – 2002 Operation of VVA

Incineration of solid low level waste

→ Chemically more stable
→ Volume reduction

Stabilization of the ashes with cement mortar in 200 l drums.
2011 Application for decommissioning
2012 ENSI expertise
2013 Public obligation
2014 Decommissioning ordinance
2015 Preparation of dismantling, building application
2016 Start of dismantling

30.05.2016
Main wastes generated:

- Aluminum
- Graphite
- Steel/Cast iron
- Concrete
- Asbestos
Aluminum from DIORIT and SAPHIR

- A significant waste from decommissioning of nuclear facilities
- Contains mainly Co-60
- Two reactor tanks from DIORIT I and II, approx. 2 x 1.5 tons
- Dose rates up to 700 mSv/h
- Various elements from SAPHIR, approx. 1.2 tons
- Cavities from proton accelerator, approx. 6.4 tons
Solution:
- Cutting of the Al-waste into pieces of 20 x 120 cm size
- Place the pieces in Al-baskets of 28 x 130 cm
- Melting the Al-baskets with the Al-waste in inductively coupled furnace into graphite/clay crucibles
Aluminium conditioning contd.

Crucibles filled with Al and placed in a PSI concrete container

- Placing the crucibles with the melted Al-waste in a concrete container (KC-T12)
- Embedding the crucibles in PSI-mortar

Result:
- Reduced reactive surface of the Al in contact with the mortar with a slightly gas evolution before hardening of the mortar. After hardening there is no gas formation anymore!
Graphite from DIORIT

- A significant waste from decommissioning of nuclear facilities

- Contains long-lived nuclides C-14, Cl-36

- Stable mineral matrix (stable under geological conditions and high pH)

- **Principles**
  - Minimise operational risks
  - Minimise environmental impact
  - Minimise costs

- **Situation**
  - About 45 t activated graphite in the DIORIT
  - in segments of about 50 kg
  - Dose rate between 30 and 2000 µSv/h
Waste Container

Grout:

Gap width 3 times of the maximum grain size

- $1.5 \text{ cm} < \text{ Graphite Mortar}$
- $1 \text{ cm} < \text{ gap} < 1.5 \text{ cm} \quad \text{Conventional Mortar}$
- $< 1 \text{ cm} \quad \text{Fine Mortar}$

Graphite Milling

Dismantling Procedures and Options
Graphite Mortar

Grain size < 5 mm
Technical achievement

- High content of graphite (env. 50%) ✓
- Flowability ✓
- Homogeneity ✓
- No segregation of water ✓
- Moderate temperature development ✓
- Compressive strength above 10MPa ✓
- Low leachability ✓
Thank you very much for your attention!