Fritz Leibundgut :: Decommissioning Officer :: Paul Scherrer Institut

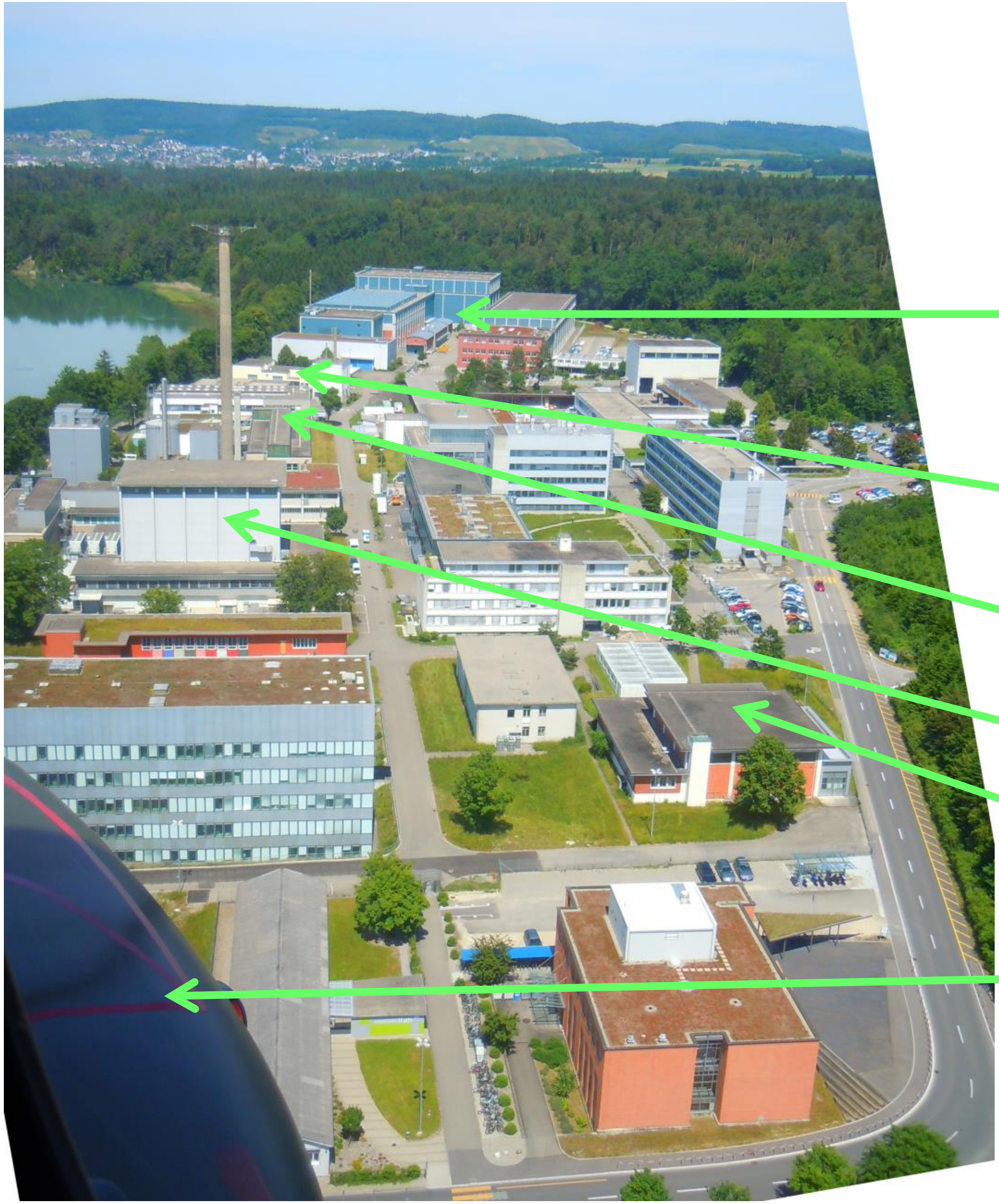
Decommissioning of Nuclear Facilities in Switzerland – Lessons learned

HRP/IAEA/NEA Decommissioning workshop – February 7, 2017

Overview

← Basel   Germany ↑   Aarau/Bern ↓   Zürich →

Nuclear installations on the PSI area



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

*Post-operation phase/
Decomm./Dismantling

SAPHIR: 1957-1993

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

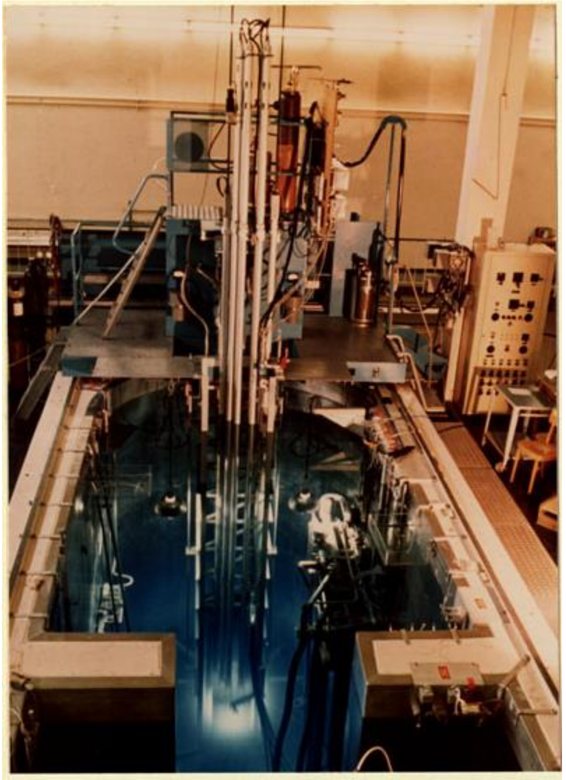
1985 Approval for 10 MW

1993 Final shutdown

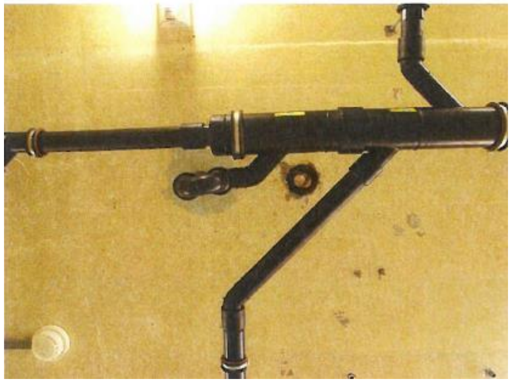
2000 Decommissioning ordinance

2008 Dismantling of the pool completed

2015 Cleanout of the KBL (“Kernbrennstofflager”)



SAPHIR: Status 2016



ENSI-Inspection at 7. of April, 2016

DIORIT: 1960-1977

Proprietary Swiss development. Goal was the construction of industrial applicable reactors for material testings and experiments.

1960 Operation with natural uranium and D_2O as coolant and moderator.

1966 Uprating from 20 MW to 30 MW.

1972 (after modification): Operation with LEU.

1977 Final shutdown.

1982 Partial dismantling; continued 1988-1993.

1994 Approval of dismantling the reactor.

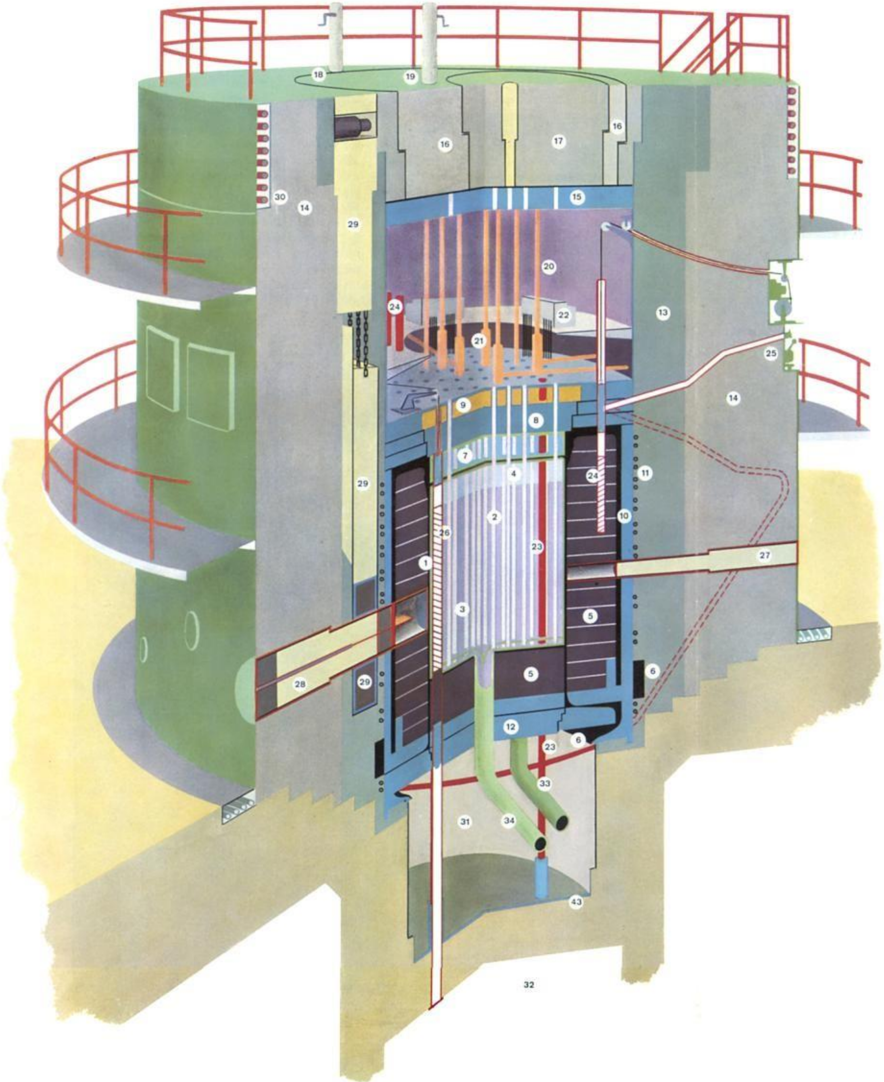
2005 Asbestos was found → interruption until 2009.

2013 Dismantling of biological shielding

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

2019 (?) 2. Decommissioning ordinance for greenfield

DIORIT



Biol. Shielding DIORIT: 2012

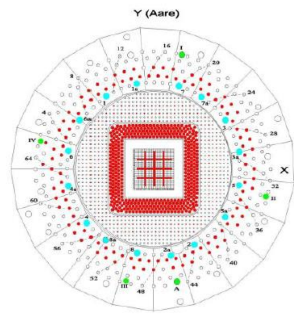
March 2012

September 2012

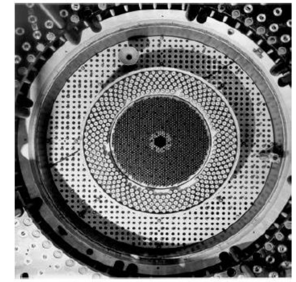
PROTEUS: 1968-2011

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

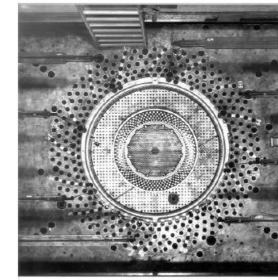
HPLWR-today



GCFR-70s

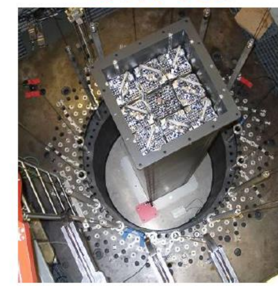


HCLWR-80s



HTR-90s

LWR-00s



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

Decommissioning of PROTEUS

2011 Final shutdown

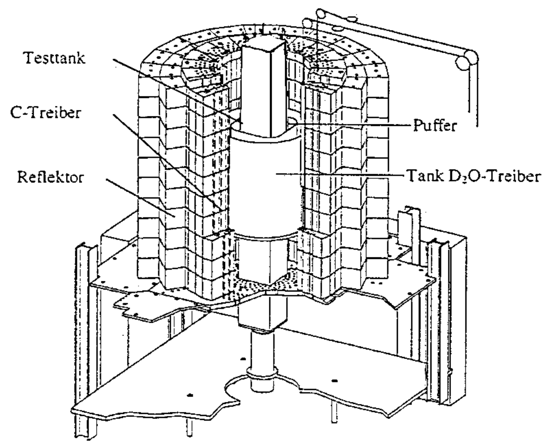
2012 Removal of fuel

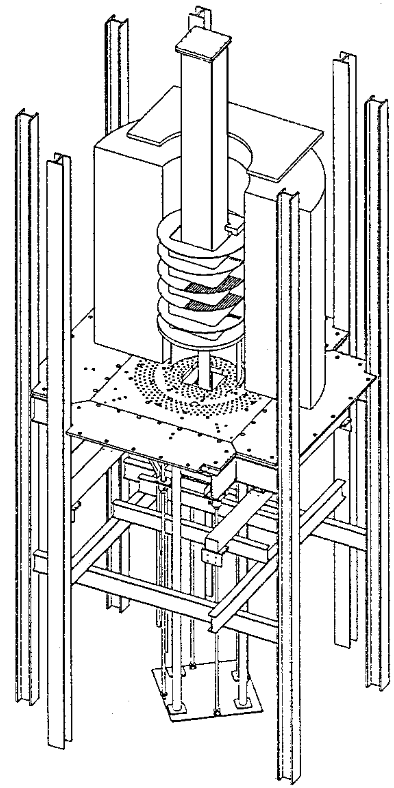
2013 Application for decommissioning

2015 Approval of post-operation phase, deactivation of reactor instrumentation.

2016 Public obligation of the project. No objection.

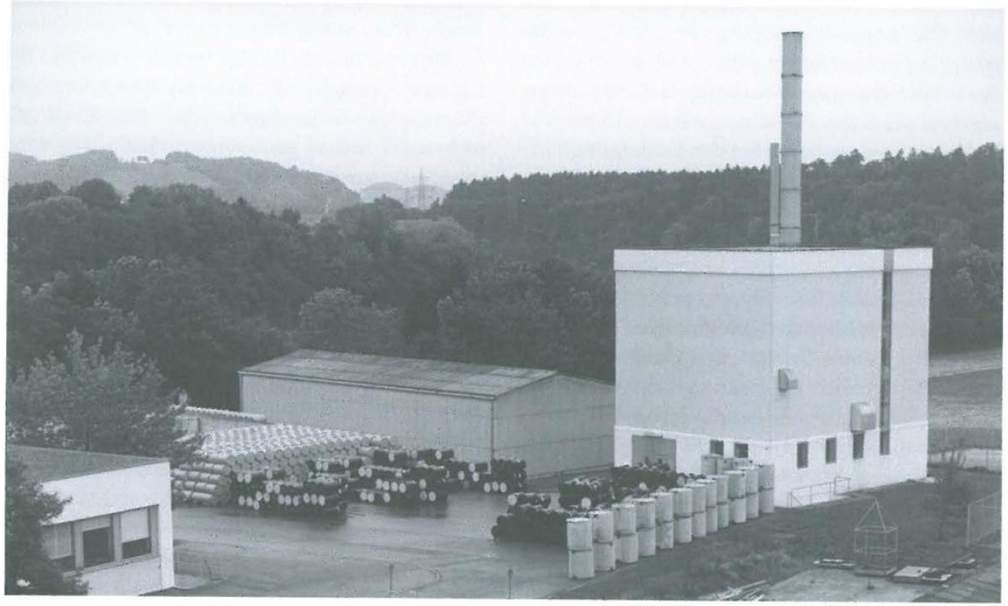
2017 (?) Decommissioning ordinance





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.

Decommissioning of VVA

2011 Application for decommissioning

2012 ENSI expertise

2013 Public obligation

2014 Decommissioning ordinance

2015 Preparation of dismantling, building application

2016 Start of dismantling

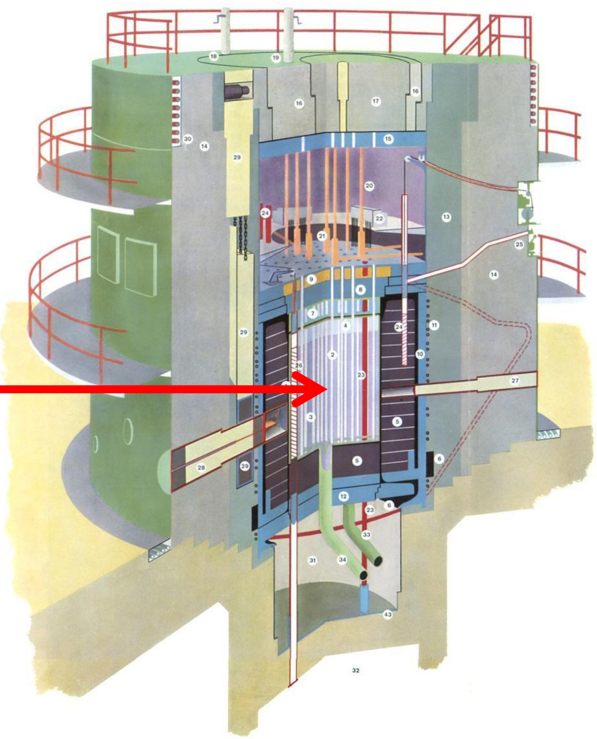
30.05.2016

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



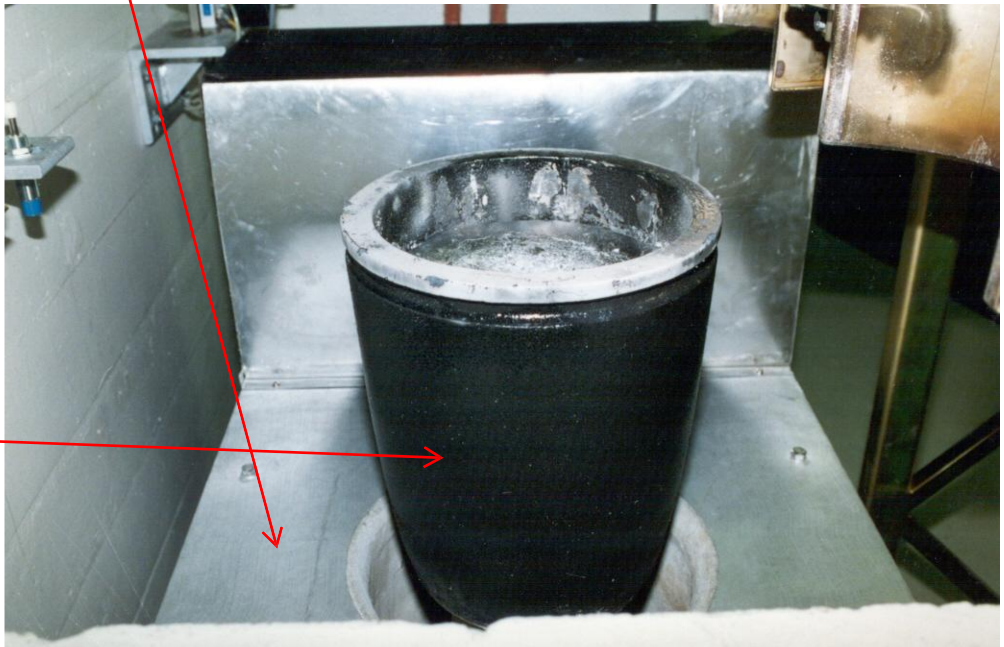
Aluminium conditioning

Al-basket

inductively coupled furnace

Solution:

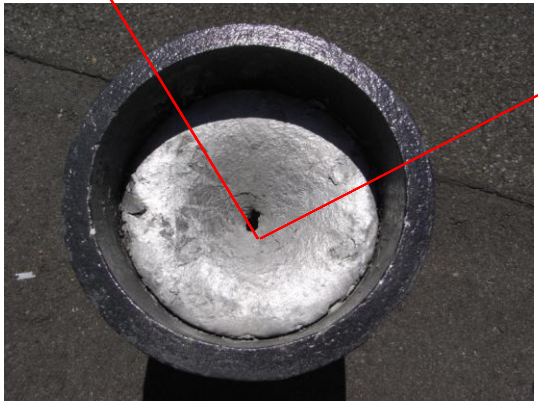
- Cutting of the Al-waste into pieces of 20 x 120 cm size
- Place the pieces in Al-baskets of 28 x 130 cm
- Melting the Al-baskets with the Al-waste in inductively coupled furnace into graphite/clay crucibles

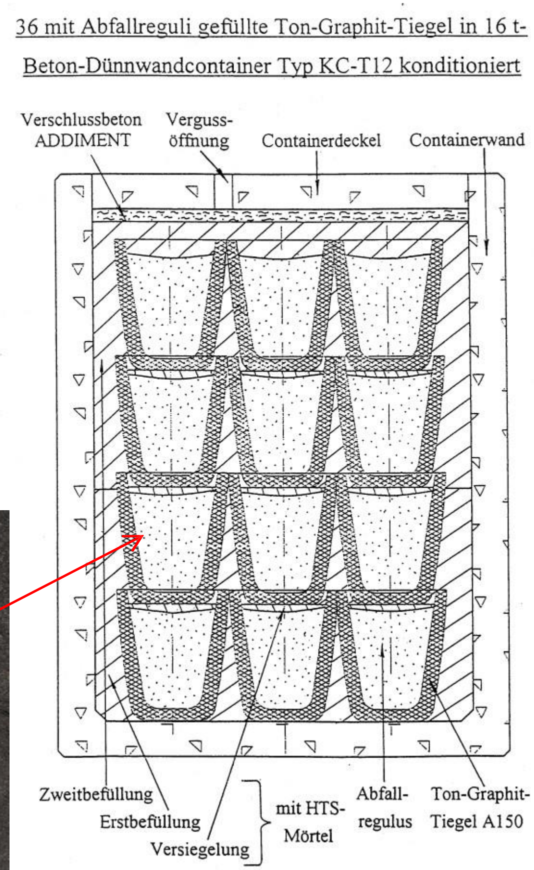


graphite/clay crucibles

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

H.-F. Beer, Complete Dismantling of the Research Reactor DIORIT, Strahlenschutzpraxis, 2013(2), p. 32-37

Aluminium conditioning contd.

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

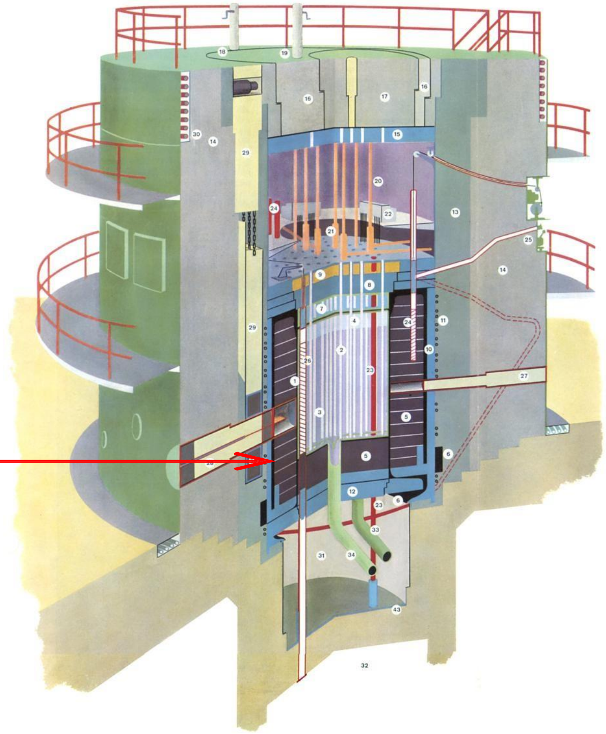
- A significant waste from decommissioning of nuclear facilities
- Contains long-lived nuclides C-14, Cl-36
- Stable mineral matrix (stable under geological conditions and high pH)

- **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



PSI-Technique

Waste Container

Grout:

Gap width 3 times of the maximum grain size

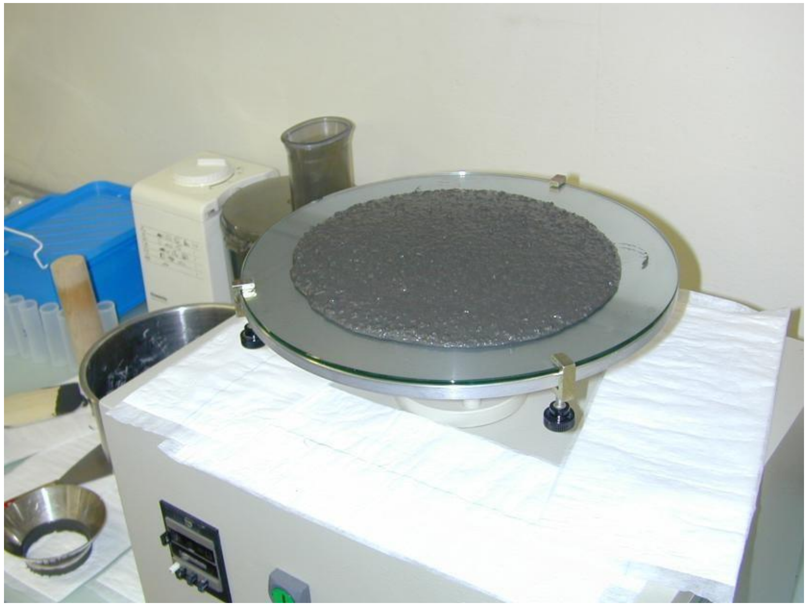
1.5 cm <	Graphite Mortar
1 cm < gap < 1.5 cm	Conventional Mortar
< 1 cm	Fine Mortar

Graphite Milling

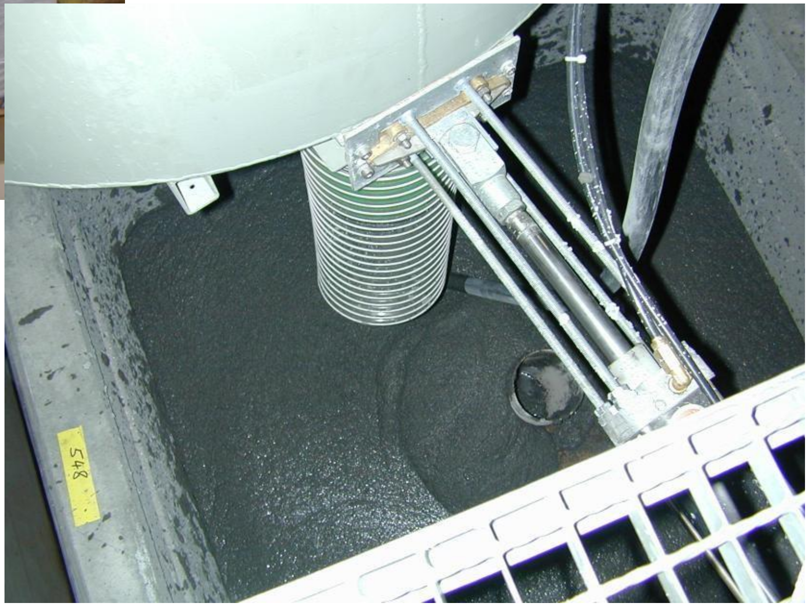
Dismantling Procedures and Options

Graphite Mortar

Grain size < 5 mm



Application of Graphite Mortar



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!