Decommissioning, Radioactive Waste and Spent Nuclear Fuel Management in Slovakia

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Decommissioning of Bohunice A1 NPP

- NPP A1 – one unit (HWGCR, 150 MW), in operation from 1972 to 1977, shut-down after the accident (INES 4)
- Decommissioning project - Stage I: general contractor is VUJE, implemented from 1996 to 2009 including management of damaged spent fuel (1996 – 1999)
- Achieving of radiation safe conditions of Bohunice A1
- Treatment and conditioning of RAW generated
- Restoration and innovation of various D&D technologies, processes and information systems providing improvement of working conditions for A1 personnel and environmental protection
- Preparation of conditions for A1 decommissioning – Stage II (ongoing from 2009)
- Customer: JAVYS (Nuclear and Decommissioning Company)
Decommissioning of Bohunice A1 NPP

Timetable of works of continuous variant of A1 decommissioning

- **Licence for operation**
  - Operation of A1 NPP
  - Putting out of operation after reactor’s shutdown
  - Project of A1 NPP decommissioning, Stage I

- **Licence for decommissioning**
  - Stage I
    - A1 NPP decommissioning, Stage I
  - Stage II
    - Decommissioning of outer active objects
  - Stage III
    - Decommissioning of low-contaminated part of main generating unit
  - Stage VI
    - Decommissioning of middle-contaminated part of main generating unit
  - Stage V
    - Decommissioning of high-contaminated part of main generating unit

- Year:
  - 1972
  - 1977
  - 1995
  - 1999
  - 2008
  - 2016
  - 2021
  - 2025
  - 2033
Decommissioning of Bohunice V1 NPP

- NPP V1 (two units, WWER-440/230 standard design) in Jaslovske Bohunice;
- Political decision to shutdown the V1 NPP was accepted by the Slovak Government in 1999;
- Shutdown of the 1st unit was done in 12/2006, 2nd unit in 12/2008;
- After decision to shutdown plant the Bohunice International Decommissioning Support Fund (BIDSF) was created as compensation by the European Union (EBRD);
- Several BIDSF projects are ongoing (A projects – the V1 NPP modifications; B projects – decommissioning documentation, database, training etc., C projects – historical RAW management, D projects – decommissioning phase).
Decommissioning of Bohunice V1 NPP

Following options were developed within the Conceptual plan:

Option 1 – Immediate Dismantling

- NPP V1 Operation
- Operation Termination
- 1st Stage of Decommissioning
- 2nd Stage of Decommissioning
- Site Release

Option 2 – Safe Enclosure under Surveillance

- NPP V1 Operation
- Operation Termination
- 1st Stage of Decommissioning
- 2nd Stage of Decommissioning
- 3rd Stage of Decommissioning
- Site Release

Option 3 – Reactor Safe Enclosure

- NPP V1 Operation
- Operation Termination
- 1st Stage of Decommissioning
- 2nd Stage of Decommissioning
- 3rd Stage of Decommissioning
- Site Release

Option 4 – Zero (no action) Option

Detailed Decommissioning 1st Stage Plan was developed from 2008 to 2011 by VUJE / DECOM / BNL
RAW management

Management of RAW – collecting, sorting, handling, transport, storage, treatment, conditioning and disposal.

Spent nuclear fuel is not considered as RAW.

Treatment of RAW is a process focused on radionuclides separation from RAW, changing its composition and reduction of the volume (evaporator).

Conditioning of RAW is a process of liquid RAW solidification to the suitable matrix.

The result is final package (FCC), which can contain various packages (e.g. 200 l drums).

The objective of RAW management are safe isolation from environment and volume reduction.
Solid RAW management

1. Pre-dismantling decontamination,
2. Fragmentation,
3. Post-dismantling decontamination (if it is necessary),
4. Transport (transport containers, pallets, drums, PE bag),
5. Sorting:
   a) incombustible (compactible – electro-installation, contaminated concrete, contaminated soils) or incompactible (rubber),
   b) combustible (PE, personal protective working means),
   c) meltable (metals, contaminated soils etc.).
Decontamination

Decontamination is used for material contaminated by radionuclides on its surface, which means preventing the process of significant diffusion of radionuclides inside.

Decontamination is used mostly for metal material and contaminated concrete.

Decontamination methods: chemical, electrochemical, abrasive (blasting, shaving, scrubbing), ultrasound, foam, by using paste and solvents, sticking foils, removable paint coat agents, remelting, by pressure.
Decontamination

Blasting

High-capacity decontamination unit

VUJE, Inc., Okružná 5, 918 64 Trnava, the Slovak Republic
Fragmentation

According to the place of implementation:
on site (in situ) or on fragmentation workplace.

According the physical principle:
dry (cutting, shearing, burning etc.) or wet (water jet).

According to temperature gradient against the surroundings:
  a) low-temperature (up to 40°C),
  b) medium-temperature (up to 500°C),
  c) high-temperature (above 500°C).
Fragmentation

JAVYS, TSÚ RAO, Fragmentation workplace
Liquid RAW management

1. Transport of the concentrate (transport containers, active pipeline channels);
2. Concentration (boiler or film evaporators, through-flow evaporator, ...);
3. Solidification: vitrification, cementation, bitumenization, ceramics (e.g. phosphate), geopolymerization etc.

Among the liquid RAW belong:

- a) concentrates,
- b) sediments from the former concentrates,
- c) resins,
- d) sludges etc.
Bohunice RAW Treatment Centre

Separation
Incineration
Super-compaction
Concentration
Cementation
The final product of the complete radioactive waste management process is a filled fibre reinforced concrete container suitable for disposal in the National Radwaste Repository in Mochovce. Before the container is sent for disposal, the package must be inspected to confirm that it meets demanding acceptance criteria at the repository.

Dimensions of FCC: 1,7 x 1,7 x 1,7 m
Maximum weight: 11,7 t
Maximum dose rate: on the surface 2 mSv/h
2 m from the surface 0,1 mSv/hour
Other RAW treatment facilities in Bohunice

- Bituminization facility operated by JAVYS
- Vitrification facility operated by JAVYS
- Discontinual bituminization facility operated by VUJE / JAVYS
- Historical Incineration facility with cementation unit in decommissioning phase
- Movable cementation facility operated by VUJE
- Facility for sorting of contaminated soil operated by VUJE
Retrieval of radioactive sludges from underground tanks

- Underground tanks were dedicated to collection of different liquid waste streams from the NPP A1 reactor building.
- Tank diameters ranged from 6 m to 16 m and their internal structure are of various types.
- Tanks were constructed from concrete with a special polyester glass reinforced laminate coating.
- Special manipulator DENAR-41 was developed for retrieval of liquid waste as well as for other purposes (retrieval of solid waste, decontamination, dismantling, cutting of internal tubes etc.).
- The main difficulties in the development of the DENAR-41 were the large diameter of the storage tanks and the small opening for the inspection access (approx. 540 mm x 540 mm), through which the manipulator’s telescopic mast is inserted into tanks.
- Another special equipment, so-called sludge-walker and gravel-walker were developed.
D&D and retrieval of radioactive sludges from underground tanks: DENAR-41

Description of DENAR-41:
1 – bearing construction, 2 – vertical unit, 3 – telescopic mast, 4-6 – adjustable robotic arm with TV system + retrieval and D&D tools, 7 – control unit

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An unique in-situ Movable Cementation Facility ZFK was designed by VUJE, Inc. It is dedicated to treatment of liquid RAW and sludge or gravel retrieved from the underground tanks.

Cementation facility is movable, it isn’t necessary to use special transportation devices for sludge between the underground tanks and the cementation facility itself.

Main equipment of the facility are installed inside standard ISO containers and thus the whole facility is relatively easy to transport and to install near any other tank with stored waste.

In-drum mixing technology is applied, standard 200 l drum with cemented product is the only output from the movable cementation facility.
In-situ Facility for Radioactive Waste Treatment ZFK
Stationary Facility: Final Treatment of Liquid RAW at NPP Mochovce

- VUJE was general supplier of technology for the new Final Treatment of Liquid RAW facility at the NPP Mochovce (2004 – 2007).
- Main treatment technologies are cementation and bituminisation on thin film evaporater.

Schedule
- Project preparation: March 2004 – May 2005
- Start of construction: August 2004
- Commissioning: July – November 2006
- Test operation: November 2006 – November 2007
Stationary Facility: Final Treatment of Liquid RAW at NPP Mochovce

The purpose of facility:

- treatment of concentrates,
- treatment of spent resins (sorbents) and sludges.

The methods:

- bituminisation on agitated thin film evaporator,
- homogenisation with melted bitumen in a batch type mixer,
- cementation of overconcentrates in a batch type mixer.
Stationary Facility : Final Treatment of Liquid RAW at NPP Mochovéce

Evaporator for overconcentrates

Room of bitumen preparation

Mixer of cement mixture
Radioactive waste disposal

National near surface disposal facility for low-level and intermediate-level radioactive waste was constructed at the end of the eighties in the locality of NPP Mochovce.

Important improvements were implemented during 1996-1998. VUJE was the general supplier of the project Completion of the Mochovce disposal facility:

- additional geotechnical investigation was performed,
- new drainage system was constructed,
- covering steel hall was constructed,
- new version of the safety report was prepared.
# Radioactive waste disposal

**Basic technical data of the National disposal facility**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site area</td>
<td>11.2 hectares</td>
</tr>
<tr>
<td>Number of disposal vaults</td>
<td>80</td>
</tr>
<tr>
<td>Number of vaults per row</td>
<td>20</td>
</tr>
<tr>
<td>Number of double-rows</td>
<td>2</td>
</tr>
<tr>
<td>Dimensions of vault</td>
<td>17.4 x 5.4 x 5.5 (LxWxH in m)</td>
</tr>
<tr>
<td>Useful volume per vault</td>
<td>510 m³</td>
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<tr>
<td>Seating capacity of vault</td>
<td>90 containers</td>
</tr>
<tr>
<td>Volume of FRC container</td>
<td>3.1 m³</td>
</tr>
<tr>
<td>Total seating capacity of disposal</td>
<td>7,200 containers</td>
</tr>
<tr>
<td>Effective fixed waste form volume</td>
<td>22,320 m³</td>
</tr>
</tbody>
</table>

*VUJE, Inc., Okružná 5, 918 64 Trnava, the Slovak Republic*
Spent nuclear fuel management

The Interim Spent Fuel Storage in Jaslovské Bohunice was established in 1987 - wet type facility.

Spent nuclear fuel from WWER type reactor is safely stored for a period of at least 50 years.

In the period from 1997 to 2001, the project of seismic strengthening and capacity increasing of the interim storage facility was done. By implementing the project, such state has been achieved that even after serious seismic event all safety functions of the interim storage facility will be secured, and all the fuel from Bohunice units will be able to be stored there till the end of the planned lifetime.
Interim Spent Nuclear Fuel Storage Facility

Storage cask for spent fuel

Storing pools

Capacity: sufficient for the storage of fuel from the expected operation of four nuclear units
Numbers of storage pools: 3 service pools and 1 reserve pool
Pool storage medium: demineralised water
Thank you for your attention

Спасибо за Ваше внимание