Management and Transportation of Spent Nuclear Fuel in Switzerland

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Nuclear Power in Switzerland (CH)

A Brief Chronology

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1955</td>
<td>UNO Conference in Geneva „Atoms for Peace“</td>
</tr>
<tr>
<td>1955</td>
<td>US Swimming Pool Reactor „SAPHIR“ purchased by CH</td>
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<tr>
<td>1957</td>
<td>SAPHIR begins operation</td>
</tr>
<tr>
<td>1961</td>
<td>First Criticality of the DJORIT Heavy Water Reactor in CH</td>
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<tr>
<td>1968</td>
<td>First Criticality of the Lucens Underground Reactor</td>
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<tr>
<td>1969</td>
<td>First Criticality of the Beznau 1 Reactor</td>
</tr>
<tr>
<td>1989</td>
<td>Cancelling of the Kaiseraugst NPP</td>
</tr>
<tr>
<td>2000</td>
<td>Commissioning of the ZWILAG Interim Storage Facility</td>
</tr>
<tr>
<td>2008</td>
<td>Commissioning of the ZWIBEZ Interim Storage Facility</td>
</tr>
<tr>
<td>2011</td>
<td>Fukushima followed by Government phase out decision</td>
</tr>
</tbody>
</table>

Nuclear Power in Switzerland

The Swiss Nuclear Park

- **NPP Beznau**: 2 x 365 MWe 1969 & 1971 PWR Westinghouse „2-loop“
- **NPP Gösgen**: 1060 MWe 1979 NPP KWU „Vor-Konvoi“
- **NPP Leibstadt**: 1200 MWe 1984 BWR GE BWR 6
- **NPP Mühleberg**: 373 MWe 1972 BWR GE BWR 4

Typical discharge burnups are 60'000 MWD/te

After 50 years of operation ~3500 te of spent fuel will have been generated of which ~ 1000 te has already been reprocessed.
The Management of Spent Fuel

The Swiss Storage & Disposal Route

post 2006

1-5 years

Reactor Ponds
10-15 years

spent fuel

either/or

spent fuel

Dry storage facility (ZWILAG or ZWIBEZ)
30 - 40 years

spent fuel & vitrified waste

Plutonium & Uranium for re-use

Final Repository

The Management of Spent Fuel

Interim Storage (dry)

Zwilag: Operational since 2001
Inventory 38/200 Casks

Zwibe: Commissioned 2008
Inventory 5/48 Casks
The Management of Spent Fuel

Interim Storage (dry)

- As a means of optimising their spent fuel disposal route, NPP Gösgen decided in 2002 to build an external cooling pond ca. 100m from the plant.
- Max. Capacity 1000 FA / 1MW
- Transfers from the plant are made dry with TN12/2 casks (4x12 FA per year)

Commissioning in 2008

Interim Storage (wet)
Transports of Spent Fuel & Waste

To ZWILAG: According to Cask Type, Content & Number

- CASTOR 28M
- TN81CH
- CASTOR HAW 20/28
- TN24BHL
- TN24BH
- TN52
- TN04G
- TN07

Graphs showing the content and number of transports from 2001 to 2015, with categories for Reprocessing Waste and Spent Fuel.
Transports of Spent Fuel & Waste

A convoy of 3 Vitrified Waste Casks arriving at Zwilag
Transports of Spent Fuel & Waste

A Vitrified Waste Cask being transferred onto a low loader at Zwilag

Transport and Storage Casks

Developments over the past 15 Years of interim storage in CH

- Generally, dual purpose casks are used for interim storage at ZWILAG & ZWIBEZ
- First of all “old & cold” fuel was used and loaded into high capacity casks
- As hotter fuel needed to be stored, more sophisticated casks were needed
- Modern, high burnup fuels are beginning to push the limits of current casks
- Originally, only one spent fuel cask supplier was used / available
- With the introduction of more sophisticated designs, new suppliers have emerged
- Experience has taught us that diversity of supply is imperative
### Transport and Storage Casks

#### Casks in Use / in Licensing Process

<table>
<thead>
<tr>
<th>Cask Type</th>
<th>Type</th>
<th>Capacity</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>TN97L</td>
<td>BWR</td>
<td>97</td>
<td>licensed, stored but no longer in active use</td>
</tr>
<tr>
<td>TN52L</td>
<td>BWR</td>
<td>52</td>
<td>licensed, stored but no longer in active use</td>
</tr>
<tr>
<td>TN24BHL / BH</td>
<td>BWR</td>
<td>69</td>
<td>licensed, currently in use</td>
</tr>
<tr>
<td>TN NOVA</td>
<td>BWR</td>
<td>69</td>
<td>in licensing process</td>
</tr>
<tr>
<td>HISTAR 180L</td>
<td>BWR</td>
<td>69</td>
<td>potential candidate</td>
</tr>
<tr>
<td>CASTOR V/52</td>
<td>BWR</td>
<td>52</td>
<td>potential candidate</td>
</tr>
<tr>
<td>TN24G</td>
<td>PWR</td>
<td>37</td>
<td>licensed, stored but no longer in active use</td>
</tr>
<tr>
<td>TN24GB</td>
<td>PWR</td>
<td>37</td>
<td>licensed, currently in use</td>
</tr>
<tr>
<td>HISTAR 180</td>
<td>PWR</td>
<td>37</td>
<td>in licensing process</td>
</tr>
<tr>
<td>CASTOR V/19</td>
<td>PWR</td>
<td>19</td>
<td>in licensing process</td>
</tr>
<tr>
<td>CASTOR HAW 20/28</td>
<td>HAW</td>
<td>28/20</td>
<td>licensed, stored but no longer in active use</td>
</tr>
<tr>
<td>CASTOR 28M</td>
<td>HAW</td>
<td>28/20</td>
<td>licensed, currently in use</td>
</tr>
<tr>
<td>TN81</td>
<td>HAW</td>
<td>28/20</td>
<td>licensed, currently in use</td>
</tr>
</tbody>
</table>

#### Various cask designs

- TN24 Series
- HISTAR 180
- CASTOR V/19
- TNNOVA
Regulatory Requirements and Issues

Transport approval

- Transport of Nuclear Material governed by IAEA Safety Standards
- These Standards are updated every 5-7 years (currently SSR-6 (2012))
- A package approval is granted by assessing the SAR for the package against these Standards
- The approval for a package Type is generally provided by the country of origin, and is normally valid for 5 years
- Package cannot be grandfathered over several revisions of the Standards
- In addition, national & international transport regulations apply for the transport itself (ARD, RID)
- The Package types B(Unilateral)F and B(Multilateral)F are of relevance
- Standards require a demonstration of the ability to withstand a series of accident conditions during transport (Drop Test / Thermal Test / Immersion Test)

Storage approval

- Storage Approval is provided by the country in which the Package will be stored on the basis of the T(opical) SAR
- In Switzerland, this is governed by guidelines (G05, G04), which impose their own criteria on the package:
  - Resistance to static and dynamic loads: including aircraft impact
  - Requirements for the lid system: double lid
  - Requirements for the leaktightness: continual surveillance
  - Criticality requirements: by flooding
  - Material ageing: over the assumed storage period
  - Requirements on pressure barriers: all welds can be tested
  - Resistance to Aircraft impact: scale test or transfer of similar test results
  - Resistance to effects of earthquake: casks should not topple
  - Dose rates: surface < 0.5mSv/h average
  - Temperature of the contents: temperature limits to preclude degradation
  - Temperature of the cask surface: 120°C
  - Removability of fuel: during the storage period
Regulatory Requirements and Issues

Current Issues

- Transportability of casks after extended storage (formal, technical)
  - Advances in materials & cask designs

- Behaviour of contents during storage
  - Large body of knowledge: [https://euronuclear.org/events/topfuel/topfuel2015/index.htm](https://euronuclear.org/events/topfuel/topfuel2015/index.htm)

- Optimisation of Post Operation Phase
  - Just economics

- High Burn Up and MOX Fuel
  - Advances in cask designs
  - Trend to reduced loadings

The Quest for a Waste Repository in Switzerland

Siting

Siedlungsgebiete

- Optimal: Potenzialgebiet Standortgebiet Zürcher Weinland
- Reservegebiet: Optimierung
- Reservegebiet Untere Säntisverwaltung (USV)
- Reservegebiet Unterhautungsgebiet USM

Kreislaufgebiete

- Untersuchungsgebiet Motorwachtal
- Potenzielle Untersuchungsgebiete
- Untersuchungsgebiet: Zentralkraftwerk Tüntenwein
The Quest for a Waste Repository in Switzerland

Concept

- Pilot Facility
- LMA
- Main Repository HAA BE
- Test Laboratory
- Ventilation Shaft
- Ramp
- Reception Facility

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- LMA
- Pilot Facility
- Test Laboratory
- Reception Facility
- Ventilation Shaft
- Main Repository HAA BE
The Quest for a Waste Repository in Switzerland

**Timescales**

![Diagram showing timescales for waste repository in Switzerland]

**Siting**

![Map showing potential sites for a waste repository in Switzerland]
The storage route for spent fuel and reprocessing waste in CH is well established.
National and International road and rail transports take place regularly without public/media attention.
The importance of a stable and reliable long term storage is being emphasised by current events (Premature plant shut downs and repository siting).
There are some technical issues associated with long term storage of spent fuel but these are not insurmountable.
The transportability of casks after storage is an issue but is being addressed at a high level.
"Conflicting" requirements for storage & transport potentially leading to overregulation.

Summary

Thanks for your attention !!!

... some final impressions