Management of Spent Fuel at Shutdown Reactor Sites

Peter Dyck
June 2018
Overview

- The new situation in Germany
- Stand alone SF storage facilities
- The three types of SFS facilities at reactor sites
- NPP shut down with at reactor SF storage facilities
- NPP in operation with the planned shutdown dates with at reactor SF storage facilities
- Storage of damaged fuel rods
- Autarkic operation of SFS facilities
New Situation in Germany

The Federal Republic of Germany took over the responsibility for storage, final disposal, and building a repository for spent fuel and waste. The central, stand alone spent fuel storage facilities in Ahaus, Gorleben, and Greifswald were already turned over to the new organization BGZ.

All other spent fuel storage facilities at the different reactor sites will be turned over to BGZ by end of 2018, the waste storage facilities by 2020.
New Situation in Germany

The utilities will be responsible for the decommissioning of their facilities, the Federal Republic for storage and final disposal. The utilities have to load the spent fuel storage casks and condition the waste according to the specification by the Federal Republic and turn the packages over to BGZ.
Spent Fuel Storage in Germany

After the decision to stop reprocessing by 2005 all spent fuel from shut down and still operating NPPs is stored in dual purpose casks (for transport and storage).

At each NPP site were interim spent fuel facilities built to avoid spent fuel transports outside the NPP sites.

These facilities are operated in addition to the earlier built regional interim storage facilities in Gorleben and Ahaus.
Spent Fuel Storage in Germany

1082 casks are stored in the different interim storage facilities including PWR, BWR, THTR, and HLW casks.

The casks are secured by a double lid-, double gasket and pressure surveillance system against the release of radioactive material.

Germany has already a long-term experience with this kind of storage system without any problems.
Interim storage facilities for spent nuclear fuel in the Federal Republic of Germany

- On-Site Interim Storage Facility in operation
- On-Site Interim Storage Facility applied for
- Central Interim Storage Facility

- Brunsbüttel (BWR)
- Brücker (PWR)
- Krümmel (BWR)
- ZLN
- TBL Görlaben
- Unterweser (PWR)
- Emsland (PWR)
- Grohnde (PWR)
- TBL Altenkirchen
- AVR- Behälterlager Jülich
- Biblis (PWR)
- Philippsburg (PWR/BWR)
- Obrigheim (former PWR)
- Neckarwestheim (PWR)
- Gundremmingen (BWR)
- Grafenrheinfeld (PWR)
- Isar (PWR/BWR)
Standalone Facilities
Gorleben Site
Gorleben Storage Area
Ahaus Storage Site
Ahaus Storage Area

Östliche Hallenhälte
Ahaus Storage Area
Greifswald Storage Site
Greifswald Storage Area
Three Types of Spent Fuel Storage Facilities at the Reactor Sites
Steag Storage Design
Steag Storage Design
Emsland Storage Facility
Emsland Storage Facility

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WTI Storage Design
WTI Storage Design
Gundremmingen Storage Facility
Gundremmingen Storage Facility
GKN tunnel Storage Design
GKN tunnel Storage Design

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GKN tunnel Storage
NPPs Shutdown

- Würgassen, Stade, fuel reprocessed, no SFS facility
- Brunsbüttel (KKB), BWR
- Krümmel (KKK), BWR
- Unterweser (KKU), PWR
- Biblis A + B (KWB A + B), PWR
- Phillipsburg-1 (KKP-1), BWR
- Obrigheim (KWO), PWR
- Neckarwestheim-1 (GKN-1), PWR
- Grafenrheinfeld (KGG), PWR
- Isar-1 (KKI-1), BWR
- Gundremmingen B (KRB-B), BWR
NPPs in operation with the planned shutdown dates

- Phillipsburg-2 (KKP-2), PWR 2019
- Gundremmingen-C (KKG-C), BWR 2021
- Brokdorf (KBR), PWR 2021
- Grohnde (KWG), PWR 2021
- Emsland (KKE), PWR 2022
- Neckarwestheim-2 (GKN-2), PWR 2022
- Isar-2 (KKI-2), PWR 2022
### Number of Casks Stored

<table>
<thead>
<tr>
<th>Storage Facility</th>
<th>Casks Stored</th>
<th>Types of Casks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brunsbüttel</td>
<td>20</td>
<td>CASTOR V/52</td>
</tr>
<tr>
<td>Krümmel</td>
<td>41</td>
<td>CASTOR V/52</td>
</tr>
<tr>
<td>Brokdorf</td>
<td>30</td>
<td>CASTOR V/19</td>
</tr>
<tr>
<td>Unterweser</td>
<td>39</td>
<td>CASTOR V/19</td>
</tr>
<tr>
<td>Grohnde</td>
<td>30</td>
<td>CASTOR V/19</td>
</tr>
<tr>
<td>Grafenrheinfeld</td>
<td>21</td>
<td>CASTOR V/19</td>
</tr>
<tr>
<td>Isar</td>
<td>45</td>
<td>26 CASTOR V/19, 12 CASTOR V/52, 7 TN24E</td>
</tr>
<tr>
<td>Emsland</td>
<td>43</td>
<td>CASTOR V/19</td>
</tr>
<tr>
<td>Biblis</td>
<td>91</td>
<td>CASTOR V/19</td>
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<tr>
<td>Gundremmingen</td>
<td>58</td>
<td>CASTOR V/52</td>
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<tr>
<td>Neckarwestheim</td>
<td>77</td>
<td>57 CASTOR V/19, 5 TN24E, 15 CASTOR 440/84mvk</td>
</tr>
<tr>
<td>Philippsburg</td>
<td>62</td>
<td>33 CASTOR V/19, 29 CASTOR V/52</td>
</tr>
<tr>
<td>Gorleben</td>
<td>113</td>
<td>5 fuel casks, 108 HAW casks</td>
</tr>
<tr>
<td>Ahaus</td>
<td>329</td>
<td>PWR, BWR, and THTR casks</td>
</tr>
<tr>
<td>ZLN Greifswald</td>
<td>83</td>
<td>75 CASTOR 440/84, 3 KRB-MOX, 5 HAW</td>
</tr>
</tbody>
</table>

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Fuel Transport KWO - GKN

It was decided to transport the 15 CASTOR 440/mvk casks with the Obrigheim fuel on the river Neckar to the NPP Neckarwestheim to avoid to built a small spent fuel storage facility at the shut down NPP Obrigheim site.

The 15 casks were shipped in five transports between June 28 and December 19, 2017.

The casks are stored in the GKN interim spent fuel storage together with the CASTOR V/19 and TN24E casks with GKN spent fuel.
Fuel Transport KWO - GKN
Fuel Transport KWO - GKN
CASTOR V/19 and CASTOR 440/mvk casks in GKN storage
Planning of cask loadings

- 2018  loading of up to 74 Castor V
- 2019  loading of up to 60 Castor V
- 2020  loading of up to 35 Castor V
Pending Licenses in Germany

• Storage of casks loaded with encapsulated damaged fuel in CASTOR V casks

• Storage of TN24E casks in KBR and KKP

• Storage of casks with HLW from France and UK reprocessing in KBR, KWB, KKP, and KKI
Encapsulation techniques of Damaged Fuel Rods
TOP 2  Vorstellung SWR-KSBS

Beschreibung des SWR-KSBS

a) Kopfstück
b) Verbindungselement

Fußstück

Werkstoff aller Komponenten: nichtrostender austenitischer Stahl

Schraub-/Schweißdeckel

18 AR
14 AR
8 AR

Grundkörper

Innenkorbvarianten

SWR-KSBS
Encapsulation Process of SFR for Long Term Storage in Transport and Storage Casks

**Step 1**
Transfer of the Defective Fuel Rod into the Fuel Rod Capsule

**Step 2**
Transfer of the loaded Fuel Rod Capsule to the encapsulation facility

**Step 3**
Single drying of the Def. Fuel Rod welding of the Fuel Rod Capsule and NDT of the welds

**Step 4**
Transfer of the finalized Fuel Rod Capsule into the Capsule Canister

**Cask Supplier**
- Step 5: Transfer of the loaded Capsule Canister into the Transport Storage Cask
- Step 6: Transfer to the interim storage on-site

**Definition of Special Fuel Rods and Technology of Encapsulation**
- SAM / AREVA informal Meeting – W. Hummel – All rights are reserved, see liability notice.
Encapsulation

Fuel Rod Capsule

Top end sealing plug, partly open

Top end sealing plug, closed

Particle filter

Capsule tube

Lower end sealing plug partly open

Lower end sealing plug closed

Weld seam after drying defective fuel rod

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Encapsulation Facility in the SF Pool

- **Drying**
  - Drying by hot gas circulation and exchange of saturated steam by dry gas
  - On-line supervision of residual steam moisture

- **Welding**
  - Automated welding after drying and screwing of the plugs
  - Non-destructive examination
  - The method will meet the strict requirements for retention of radioactivity for interim storage
Encapsulation
PWR & BWR Capsule Canister like Skeletons

For use at a PWR:
loading capacity up to 92 fuel rod capsules

For use at a BWR:
loading capacity up to 33 fuel rod capsules

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Encapsulation Process of SFR for Interim Storage in Transport and Storage Casks

Preparation of the SFR, Loading into a FR Capsule
Transfer to Encaps. Facility
Single rod drying, Welding of FR Capsule, NDT of the welds
Loading into Capsule Canister
Loading into Transport/Storage Cask
Transfer to Interim Storage

Fuel Services

Cask Supplier

Special Fuel Rod (SFR)  Fuel Rod (FR) Capsule  Encapsulation Facility  Capsule Canister  Transport / Storage Cask
Autarkic Operation of a Spent Fuel Storage Facility
What is necessary?
Personnel

• Management
• Shift supervisor
• Shift personnel
• Stand-by duty
• Radioprotection
• Physical protection personnel
• Registration
• Other personnel
Water Management

- Potable water
- Water for fire protection
- Sanitary waste water
- Rainwater removal
- Groundwater monitoring
Buildings and Structures

- Transportation routes
  - Roads
  - Rail
- Functional buildings
- Buildings for supply and removal
- Fencing
Electrical Engineering

- Medium voltage distribution
- Illumination
- Control and communication systems
- Hazard alert system
- Monitoring system
- Electronic data processing systems
- Server, etc.
Safety Installations

- Facility protection
- Fire protection
  - Preventive fire protection
  - Fire defence
  - Structural fire protection
Radiation Protection

• Individual monitoring
• Surrounding monitoring
• Meteorological measuring system
• Mobile measuring equipment
• Reporting system
• Safeguards
Maintenance and Quality

- Cask maintenance
- Maintenance systems for systems and components
- Quality management
- Quality surveillance
- Documentation management
- Archive
- Registration
General Services

- First aid
- Stock keeping
- General administration
- Workshop
- Car pool, logistics
- Laboratory
- Sanitation
- Changing rooms, lavatories
Superior Services

- Education and training
- Commercial services
- Legal services
- Public relations
- Safeguards (EURATOM, IAEA)
- Operating manuals
- Project management
- Insurances
Thank you for your attention