Spent Fuel Management from the Prospect of a German Cask Supplier

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35th INMM Spent Fuel Management Seminar
Alexandria (VA), January 2020
The Company GNS

Founded 1974
Turn over > 250 Mio. Euro
Employees about 450

- Headquarters Essen
  - Corporate Functions
  - Project Planning and Controlling
  - Development of Casks and Equipment

- Jülich
  - Conditioning and packaging of solid LLW

- Mülheim
  - Cask assembly (SF, HLW, ILW)
  - Training and Test Facility

Subsidiaries

Sales/Project Offices in Seoul, Korea and Bristol, UK
Complete Defueling
- Delivery of CASTOR® casks
- Planning and construction of storage buildings

Full System Deco
- Drying/Dewatering of resins
- Delivery of MOSAIK® casks

Dismantling of Core Internals
- Cutting and packaging of core internals
- Engineering and activity calculations
- Delivery of MOSAIK® casks

Dismantling of Large Components
- Cutting of large components
- Transports and logistics

Dismantling of RPV
- Cutting and packaging of RPV
- Engineering and activity calculations
- Delivery of containers
Re-organisation of the responsibilities

The act on organisational restructuring in the field of nuclear waste management in Germany stipulates substantial reforms:

• The operators of nuclear power plants are responsible for the decommissioning, dismantling and professional packaging of nuclear waste

• Interim storage and final disposal are the state’s responsibility. Financed by the energy supply companies (EVU) who paid into a public fund

• Federal government took over the BGZ from the energy supply companies and the GNS – Gesellschaft für Nuklear-Service mbH on August 1, 2017

• By January 1, 2019, the licensed on-site storage facilities for spent HLW fuel elements have been transferred to BGZ

• Twelve other facilities with low- and medium level radioactive waste from German nuclear power plants have been transferred to BGZ on January 1, 2020
German Situation

Safe interim storage

Central interim storage

On-site storage facilities (since January 2019)
CASTOR® Casks by GNS

- Since the very first dry storage cask loading in 1983 the basic design principle of CASTOR® casks remains unchanged
  - **CASTOR® casks by GNS are Dual-Purpose Casks**
    - No overpack required for transportation and storage
    - Shielding is performed by the cask itself
    - Short post operational times
    - “Load & Go” / “Store & Go”
  - **CASTOR® casks consist of a monolithic DCI cask body and metal sealings in all lids of the containment**
    - No welding seams
    - Suitable for long-term storage
    - Major cost savings compared to forged steel
  - **CASTOR® casks enable permanent pressure monitoring**
    - 24/7 monitoring of sealing function
CASTOR® Casks by GNS

CASTOR® V/19
- Capacity: 19 DWR BE
- Max. Enrichment: 4.45 wt % U-235
- Max. Burn-up: 65 GWd/MTU
- Max. Heat Load: 39 kW
- Total weight (loaded): 126 t

CASTOR® V/52
- Capacity: 52 SWR BE
- Max. Enrichment: 4.25 wt % U-235
- Max. Burn-up: 65 GWd/MTU
- Max. Heat Load: 40 kW
- Total Weight (loaded): 124 t

Main Designs of the Spent Fuel Management in Germany
Cask Loadings in Germany

CASTOR® V Cask Loadings
The shutdown of eight reactors in 2011 was unprepared. Therefore the spent fuel loadings (including almost fresh fuel) were a challenge in terms of efficient timing.

The subsequent shutdowns were better prepared in terms of optimized loading scenarios.

Therefore the planned post operational time is reduced to only four years, despite burnup of up to 65 GWD.
GNS has already developed and manufactured almost 1800 casks for High Level Waste and Spent Fuel.

**Casks loaded and in interim storage:**

- Germany 1300
- Lithuania (Ignalina) 230
- Czech Republic (Dukovany, Temelin) 145
- USA (e.g. Surry) 35
- Switzerland 17
- Bulgaria (Kozloduy) 15
- Belgium 7
- South Africa 4

**Additional casks delivered to:**

- Finland, France, the Netherlands, Russia, Korea

As of December 2019
Changing

- **Germany is phasing out of Nuclear Energy**
  - Last spent fuel casks to be delivered for German market ca. 2025
  - Last casks for waste of reprocessing to be delivered ca. 2035

- **GNS Original Designs based on German Market Requirements**
  e.g. German PWR fuel features larger diameters compared to internationally established PWR fuel:
  - KWU: $\varnothing = 230$ mm
  - Areva: $\varnothing = 214$ mm
  - Westinghouse: $\varnothing = 197 / 214$ mm
  - CE-Type: $\varnothing = 207$ mm

- **Localization and Licenseability universally**
CASTOR® geo

- Customized basket design
  - Optimized for high fuel capacity

- Established design principles incl. DCI cask body
  - Major cost advantages compared to forged steel cask bodies

- Based on standardized modules and components
  - Saves time and funds for licensing

- Optimized to international crane capacities and standardized handling and dispatch of the casks
  - Savings in equipment due to standardizations

- Already 81 casks contracted for customers in Belgium and Switzerland
First Casks for New Customers

<table>
<thead>
<tr>
<th>CASTOR® geo24B</th>
<th>CASTOR® geo21B</th>
<th>CASTOR® geo32CH</th>
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</thead>
<tbody>
<tr>
<td><strong>Capacity</strong></td>
<td>24 PWR-FA / Max. 8 MOX-FA</td>
<td>21 PWR-FA</td>
</tr>
<tr>
<td>Max. Initial Enrichment</td>
<td>4.5 wt-% U-235 / 7.7 wt-% Pu&lt;sub&gt;fiss&lt;/sub&gt; (Pu+U)</td>
<td>4.4 wt-% U-235</td>
</tr>
<tr>
<td>Max. FA Burn-Up</td>
<td>55 GWd/MTU</td>
<td>55 GWd/MTU</td>
</tr>
<tr>
<td>Max. Heat Load</td>
<td>33 kW</td>
<td>29 kW</td>
</tr>
<tr>
<td>Max. Mass during Handling w/w</td>
<td>117 Mg</td>
<td>117 Mg</td>
</tr>
</tbody>
</table>

Max. Initial Enrichment: 5.00 wt-% U-235 / 4.81 wt-% Pu<sub>fiss</sub> (Pu+U)
Max. FA Burn-Up: 74 GWd/MTU
Max. Heat Load: 35 kW
Max. Mass during Handling w/w: 127 Mg
Further Developments

<table>
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<tr>
<th>CASTOR® geo26</th>
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<tbody>
<tr>
<td>Capacity</td>
<td>26 PWR-FA</td>
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</table>

- Target Market: Japan
- Foreseen for 17x17 and 15x15 FA
- License application at Japanese regulator NRA in second half of 2020

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<thead>
<tr>
<th>CASTOR® geo69</th>
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<tr>
<td>Capacity</td>
<td>69 BWR-FA</td>
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- Target Markets: Switzerland & Japan
CASTOR® CLU System

- Canister based system for internal transfer increases FA capacity with given pool crane due to smaller masses of CLU compared to standard cask
- Dual Purpose Cask with bolted double lid system for storage and public transport
- Lock mechanism for canister for easy re-opening after interim storage for final disposal or other measures
- Possibility to include already existing competitors canister system in order to exclude its various issues (e.g. SCC)

Accelerated Defueling for NPP’s having low Crane Capacities (< 100 US tons)
Handling of CLU / Canister / Cask

1. Delivery and positioning of CASTOR® cask at Truck Lock
2. Preparation of CLU with Canister
3. Loading of FA into the Canister
4. Dispatch of CLU and Canister within the Service Station
5. Transfer of CLU within the plant to the Truck Lock
6. Attachment of CLU to the lock and the CASTOR® Cask
7. Lowering of Canister from the CLU into the CASTOR® Cask
8. Dispatch of CASTOR® Cask
Licensing Procedure for CLU

10 CFR Part 71 application for transport package approval:
- Safety Analyses Report (SAR) in accordance with NRC Regulatory Guide 7.9
- Quality assurance program description (QAPD) in accordance with NRC Regulatory Guide 7.10
- Submission of SAR and QAPD in 2020
- Mock-up testing of canister and cask closure system

10 CFR Part 72 application for storage package approval:
- Submission late in the 10 CFR Part 71 Approval Phase
**OUTLOOK:** Cost-efficient storage solution using CLU system and CONSTOR® storage casks

- **The CONSTOR® cask**
  - Well established for interim storage.
  - Cost efficient cask design comparable to concrete-based canister systems.
  - Thick-walled cylindrical “sandwich” cask body with CONSTORIT for additional shielding.
  - Direct heat removal without air inlet/outlet. Therefore no corrosion problems for the steel canister expected even for long term storage.
  - Bolted lid system.
  - 100% localization established with previous contracts.
  - Transport license not required.