Innovation in the Design of the Used Fuel Storage System

ISSF 2010

CRIEPI Tokyo, November 15-17, 2010
Dry Storage & Innovation - ISSF 2010 – Tokyo, November 2010 - p.4
The Widest Experience in Spent Fuel Storage Casks

▶ An international experience
  ◆ More than 1,000 casks supplied by AREVA
  ◆ More than 230 casks manufactured in Japan by Kobe Steel

▶ AREVA’s experience in spent fuel storage
  ◆ Metallic casks - TN 24 family
    • USA, Japan, Belgium, Switzerland, Germany, Italy
    • 350 casks ordered and 239 loaded
  ◆ NUHOMS® system
    • USA, Armenia
    • 650 casks ordered and 479 casks loaded
  ◆ TN NOVA system – Our latest system
    • Switzerland
    • 15+66 units ordered for deliveries until 2049

Our dry storage solutions rely on unprecedented experience
Interim Dry Storage Technologies

2 technologies

- Dual purpose cask
- Canister system

Doel, Belgium

Calvert Cliffs, US

Prairie Island, US

Zwilag, Switzerland ... in 2014

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Dry Storage & Innovation • ISSF 2010 – Tokyo, November 2010 • p.6
TN®24 Metallic Cask Family: The Versatile Dual-Purpose Casks

Concept

- Thick shell in forged carbon steel with a welded bottom
- Two bolted lids in transport configuration
- Neutron shielding surrounding the shell
- Basket mainly based on aluminum with boron
- Passive system

Custom-made casks for the specific needs of the operators

- More than 239 casks loaded since 1990
- More than 20 versions designed for customers in the US, Europe and Japan
- TN24 casks have had proven Operating Experience in Japan since 1995. You can count on them for licencing, lead time and operation.
# The TN®24 Cask Family

<table>
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<tr>
<th>Packaging</th>
<th>Number of fuels</th>
<th>Burn-up (MWd/tU)</th>
<th>Cooling time (years)</th>
<th>Enrichment (%)</th>
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Canister Systems for Storage & Transport of Spent Fuel

Canister systems provide one of the best value ever for your money (capital & O&M)

Dry Shielded Canister

Transfer Cask and Equipment

Repository or Reprocessing Plant

Concrete Horizontal Module: NUHOMS®

Metallic Vertical Overpack: TN NOVA

Transport Cask

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Dry Storage Licensing Experience

We have the largest cask license portfolio, worldwide
A TN Team Strength: Unique Licensing Experience

- Long-term relationships with high level Nuclear Safety Authorities
  - Japan, USA, Germany, France, Belgium, Switzerland, United Kingdom…

- Numerous transport casks licensed for a wide variety of radioactive materials worldwide, including transport of spent fuel to the reprocessing facility in La Hague

- Within AREVA portfolio, a wide range of products is already licensed
  - TN 24 cask family licensed in Japan, USA and Western Europe
  - NUHOMS® system is already licensed in the USA and Eastern Europe

- The first storage cask loaded in Japan in 1995
  - TN 24 cask at Fukushima Dai-ichi NPP

- TN24 casks are now being manufactured for a Japanese electric utility
Unique Track Record:
45 Years as a Team

► No comparison to our experience: the most experienced provider of storage technology in the world

► We are the world leader, 45 years together

► Providing excellence and efficiency:
  ◆ Proven Technology
  ◆ Licensed No-Risk Approach
  ◆ Passive System
  ◆ Simple Safe Operation
  ◆ Best ALARA Radiological Performance

► Lowest cost ISFSI construction
Innovation Mandate

Mission and objective

◆ Innovation is a keystone for the strategy of the back end,
◆ Need to integrate changes and New technologies
◆ Nuclear utilities needs evolve
◆ Additional payload, acceptance of higher discharge burnups and easier licensing process

Key performance

◆ Storage capacity and economical performance
◆ Safety and ease of licensing
◆ Ease of operation and reduction of operator doses
◆ Sustainable development
◆ Proliferation issues
Innovation Process

▶ Innovation process
   - Interview customers and utilities regularly
   - Access, capture and reuse of experience feedback and knowledge
   - Creativity and idea generation
   - Screen ideas for added value
   - Selection of ideas and R&D plan

▶ Factors for success
   - Participatory innovation: creation, collaboration, communication
   - Involvement of everyone, including top management
   - Incentives

▶ ID school: AREVA logistics open space for innovation
   - Initiatives: creativity groups & creativity methods
   - Express ideas through drawings, models
   - Creative ambiance, develop participatory innovation
TN®DUO: The New Line of Dual Purpose Casks

- TN®DUO concept
  - The massive shell is composed of several forged pieces
  - Neutron shielding surrounding the forged shell
  - Aluminum heat exchanger
  - Basket mainly based on aluminum with boron

- Robust to aircraft crash
- Retrievability of stored components
- Same or similar operating procedures as TN24 family

TN®DUO in Transport configuration & in Storage configuration
Main Innovations of the TN®DUO

- A new body
- A new outer shell composed of aluminum heat conductors, resin blocks and steel external shell
- A new basket design using the metal matrix composite (MMC) with boron
- Efficient shock absorbers made of stainless steel and carbon foam
- high performance resin poured on the outside of the shell for neutron shielding
TN®DUO Advantages

The result of an intensive innovation process

- A dual-purpose cask (transport and storage) compliant with IAEA 2005 regulations
- New aluminium heat exchangers
- A new basket design
- Resin blocks
- Efficient shock absorbers
- The TN®DUO incorporates the latest advances
- Smart design features
- Same operating procedures and tools as TN®24 cask family

- **TN®DUO** = High performance dual purpose cask with stable / low cost & lead time
TN® NOVA System: The New Line of Canister System

- TN® NOVA System
  - Spent fuel stored inside a canister
  - Metallic storage overpack
  - Storage in vertical position
  - Horizontal transfer mode + cask uprighted in a vertical position for storage: no critical lift outdoors
  - Robust to aircraft crash
  - Retrievability of stored components
  - Passive system
TN® NOVA Operations

- Similar operations to NUHOMS® systems operations

- Specific operations for TN NOVA system
  - Transfer inside the TN NOVA overpack instead of a concrete horizontal module
  - Uprighting of the TN NOVA storage overpack
Main Innovations of the TN NOVA™

- New Canister loading operation: High loading flexibility
- Metallic Storage Overpack
- Anti aircraft crash system
- Shielding provided by resin plates and steel plates
- A new basket design using the metal matrix composite (MMC) with boron
- No thermal constraints on the TN®NOVA storage overpack
- New patented Storage System
TN®NOVA Advantages

The result of an intensive innovation process

- Cost effectiveness and transportability
- Separating transport and storage functions: flexibility to spent fuel strategy
- TN®Nova system is compatible with SCC free canister solutions developed by TN
- Simple and proven loading procedure
- Security of supply and manufacture with common raw goods and standard manufacturing process

➢ Pre-existing centralized storage facility will use TN®Nova system in near future (Zwilag already operating metal casks)
AREVA's innovation process relies on unprecedented experience in design, licensing and manufacturing of casks, both in Europe and Japan.

Our focus is to provide solutions minimizing costs and providing certainty in the licensing and supply chain of storage systems.

These existing and innovative solutions match the requirements of the Japanese industry.