
AREVA

Innovation in the Design of the Used Fuel Storage System

ISSF 2010

CRIEPI Tokyo, November 15-17, 2010

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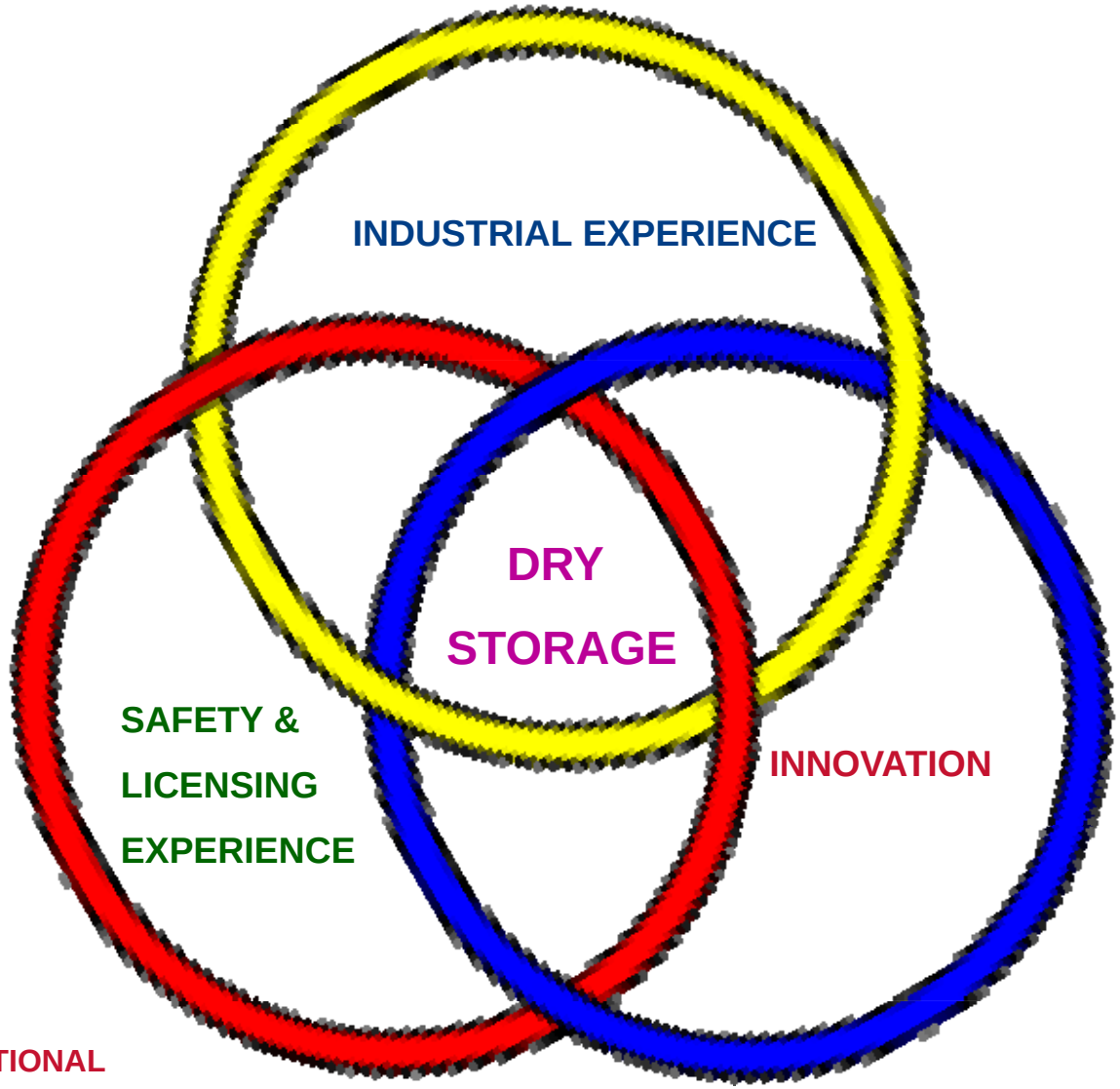
Dry Storage
The Magic Combination



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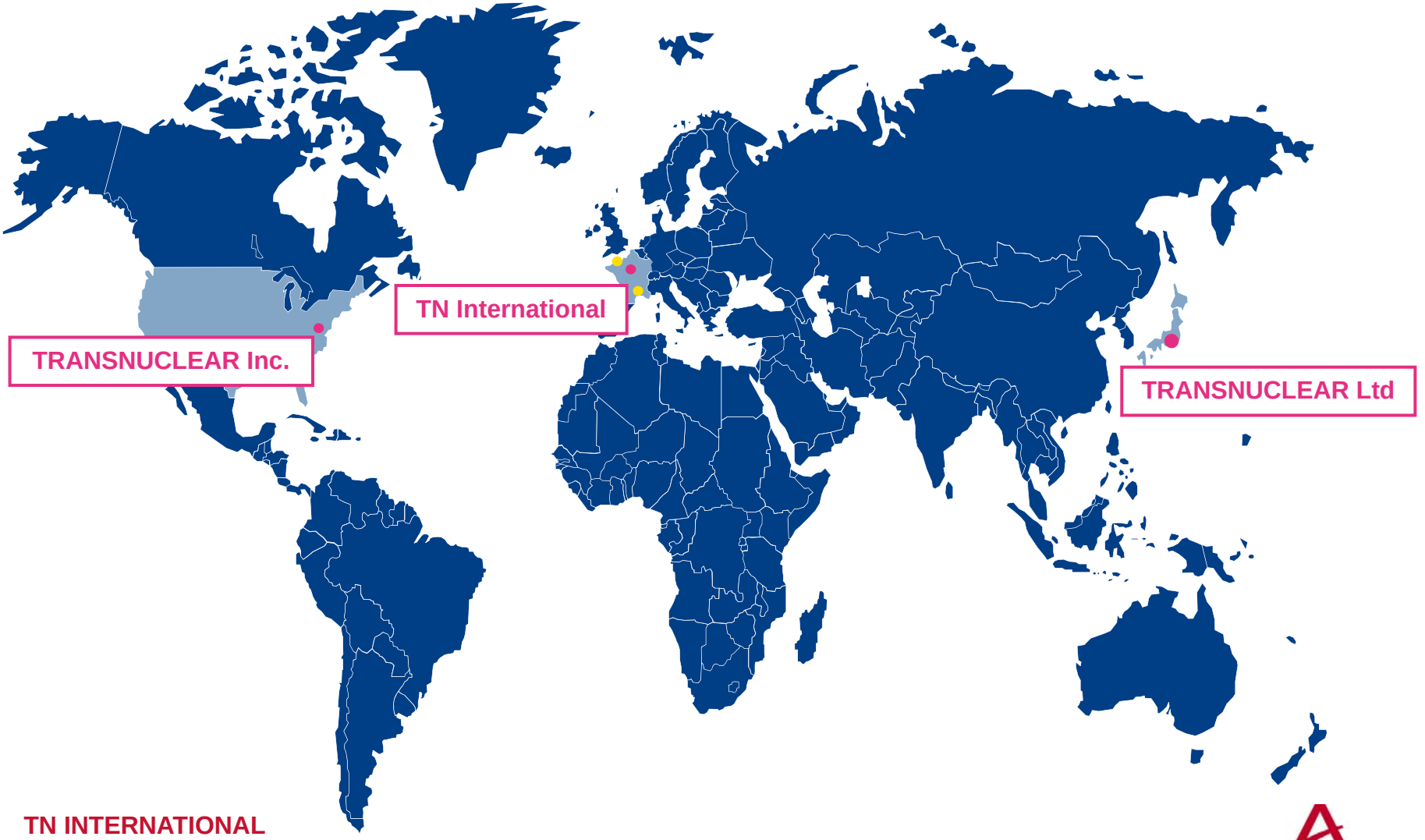
Dry Storage
Industrial Experience



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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

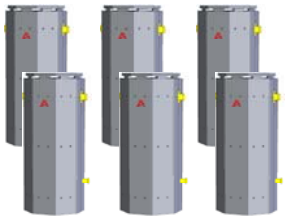
- **AREVA's experience in spent fuel storage**

Dual Purpose Systems

  - **Metallic casks - TN 24 family**
    - USA, Japan, Belgium, Switzerland, Germany, Italy
    - 350 casks ordered and 239 loaded

Canister Systems

  - **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

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Interim Dry Storage Technologies

2 technologies

Dual purpose cask

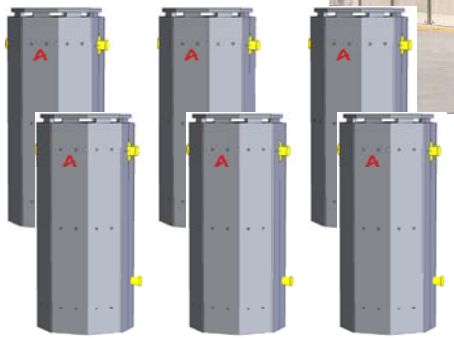
Doel, Belgium

Prairie Island, US

Canister system

Calvert Cliffs, US

Duan Arnold, US



Zwilag, Switzerland … .in 2014

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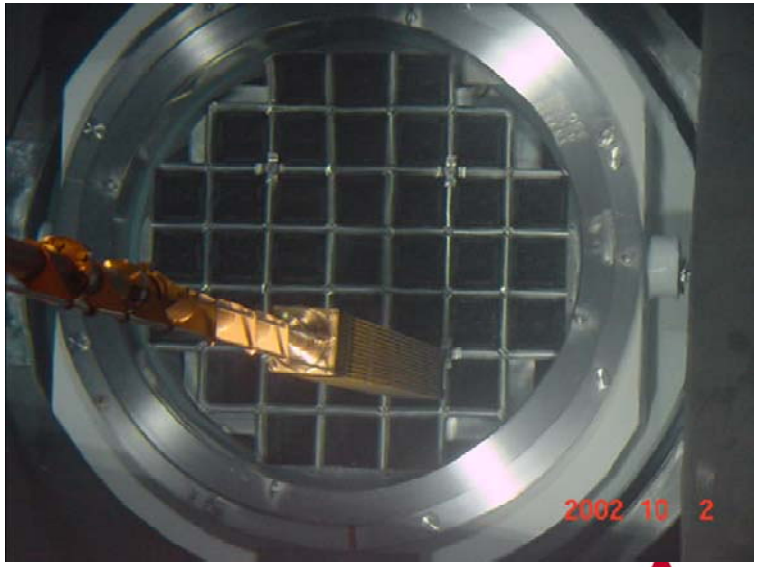
TN®24 Metallic Cask Family: The Versatile Dual-Purpose Casks

- **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 .**

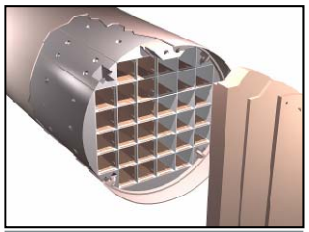


The TN®24 Cask Family

Packaging	Number of fuels	Burn-up (MWd/tU)	Cooling time (years)	Enrichment (%)	Country
TN 24 D	28 PWR	36 000	8	3.4	B
TN 24 DH	28 PWR	55 000	7	4.1	B
TN 24 XL	24 PWR	40 000	8	3.4	B
TN 24 XLH	24 PWR	55 000	7	4.3	B
TN 24 SH	37 PWR	55 000	5	4.25	B
TN 24 G	37 PWR	42 000	10	3.81	CH
TN 24 (F1*)	37 BWR	33 000	4	3.2	J
TN 24 E	21 PWR	65 000	5	4.65	G
TN 32	32 PWR	45 000	7	4.05	US
TN 40	40 PWR	45 000	10	3.85	US
TN 24 P	24 PWR	33 000	5	3.5	US
TN 52 L	52 BWR	55 000	mini 2.5	4.95	CH
TN 24 SWR	61 BWR	70 000	mini 5.5	5.0	G
TN 68	68 BWR	45 000	7	4.4	US
TN 97 L	97 BWR	35 000	10	4.0	CH
TN 24 BH	69 BWR	50 000	6	5.0	CH
TN 24 (F1*)	52 BWR	33 000	4	3.2	J
TK 69	69 BWR	40 000	10	3.2	J
TN 24 ER	32 BWR (Th)	13 700	40	5.2	I

Canister Systems for Storage & Transport of Spent Fuel

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

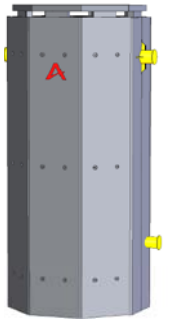


Dry Shielded Canister

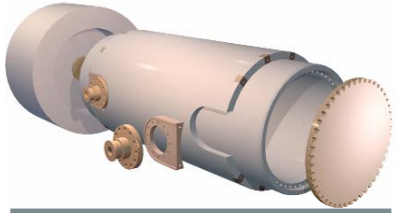
Transfer Cask and Equipment

Repository or Reprocessing Plant

Concrete Horizontal Module: NUHOMS®

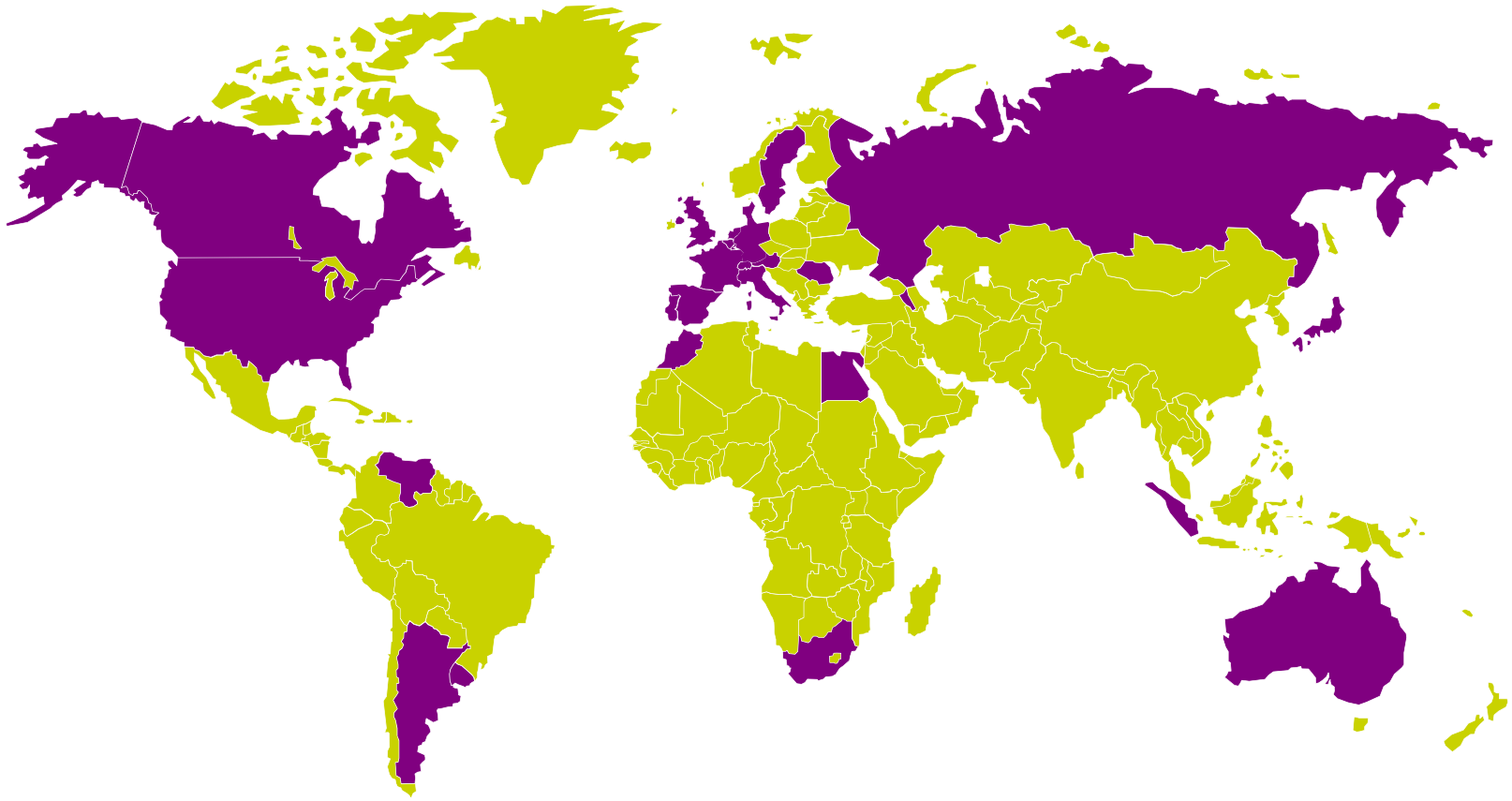


Metallic Vertical Overpack: TN NOVA



Transport Cask

Dry Storage Licensing Experience



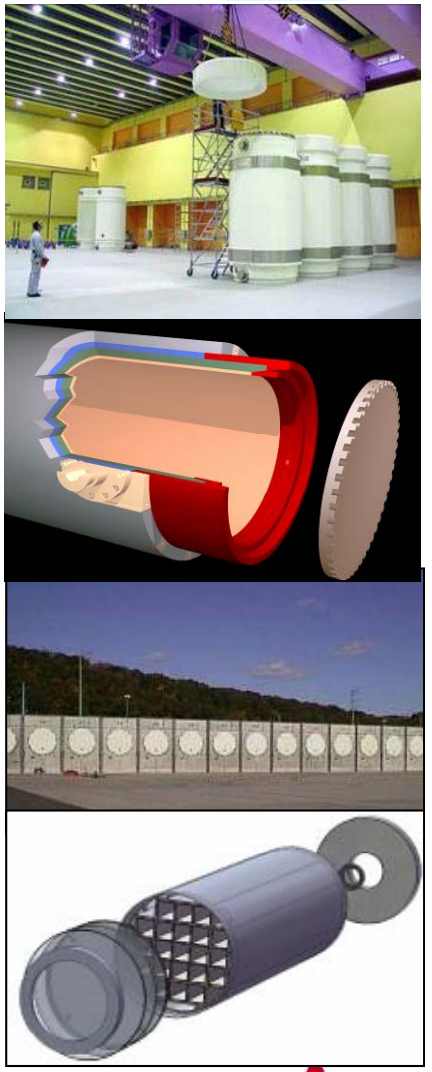
We have the largest cask license portfolio, worldwide

A TN Team Strength: Unique Licensing Experience

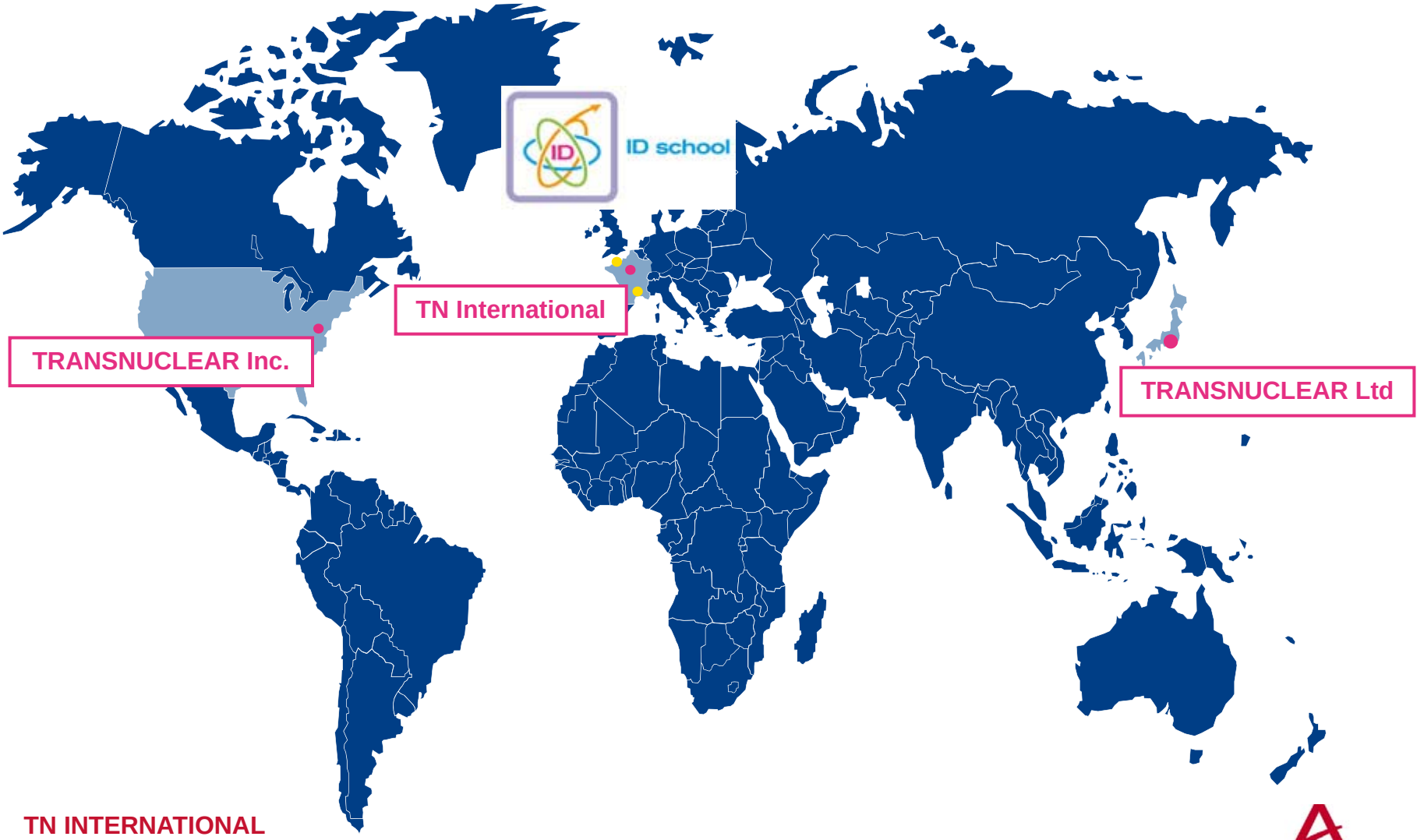
- **Long-term relationships with high level Nuclear Safety Authorities**
  - **Japan, USA, Germany, France, Belgium, Switzerland, United Kingdom…**
- **Numerous transport casks licensed for a wide variety of radioactive materials worldwide, including transport of spent fuel to the reprocessing facility 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**



Dry Storage Innovation



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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

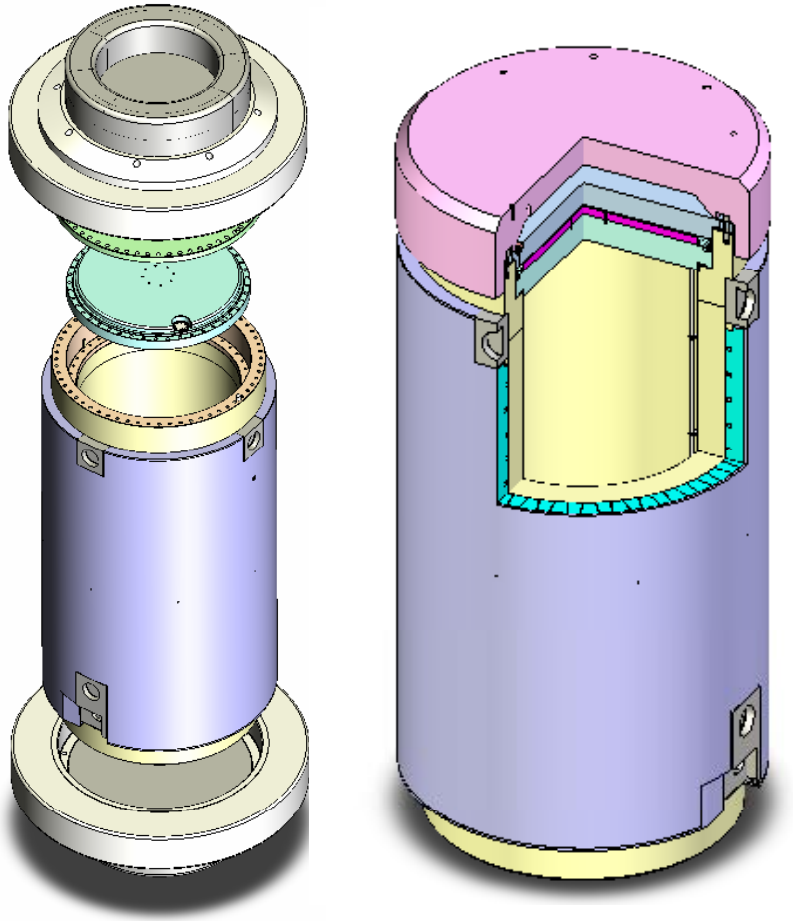
- Participatory innovation: creation, collaboration, communication
- Involvement of everyone, including top management
- Incentives

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

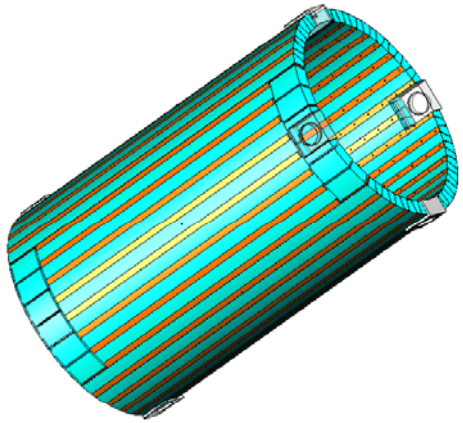
- **TN®DUO concept**
  - **The massive shell is composed of several forged pieces**
  - **Neutron shielding surrounding the forged shell**
  - **Aluminum heat exchanger**
  - **Basket mainly based on aluminum with boron**
- **Robust to aircraft crash**
- **Retrievability of stored components**
- **Same or similar operating procedures as TN24 family**

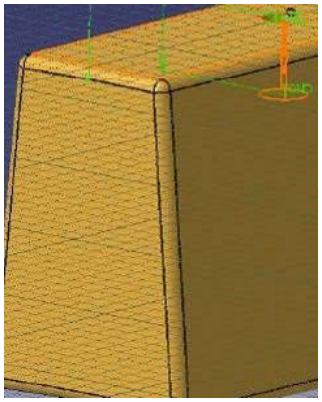


TN®DUO in Transport configuration & in Storage configuration

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



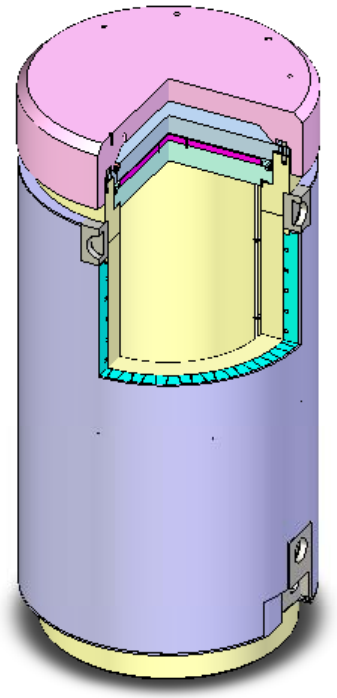


TN®DUO Advantages

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

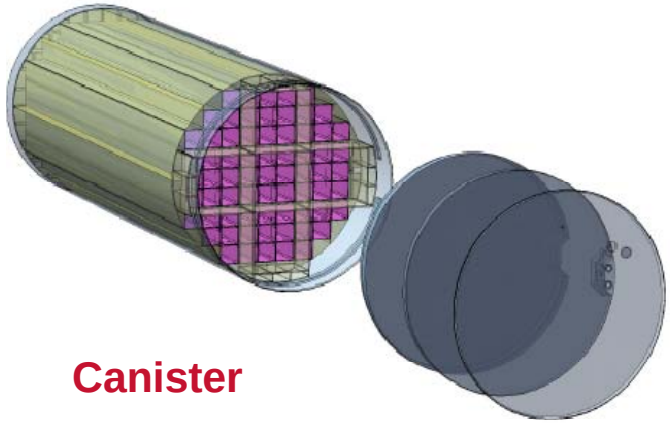
TN®DUO



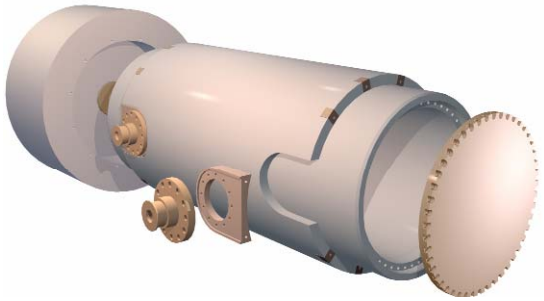
➢ **TN®DUO = High performance dual purpose cask with stable / low cost & lead time**

TN® NOVA System: The New Line of Canister System

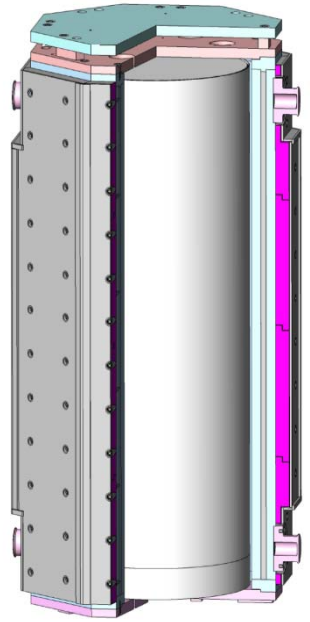
- **TN ®NOVA System**
  - Spent fuel stored inside a canister
  - Metallic storage overpack
  - Storage in vertical position
  - Horizontal transfer mode + cask uprighted in a vertical position for storage : no critical lift outdoors
  - Robust to aircraft crash
  - Retrievability of stored components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



Canister



Transport cask



Storage Overpack

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

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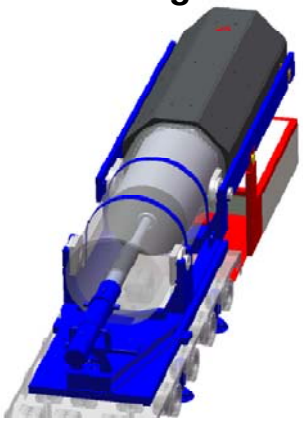

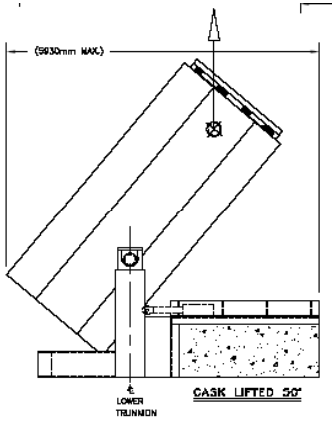

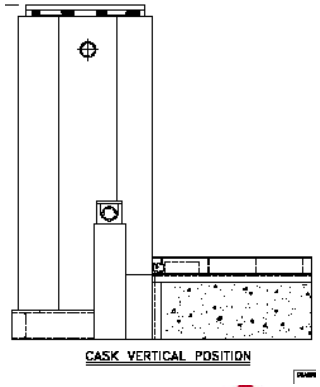

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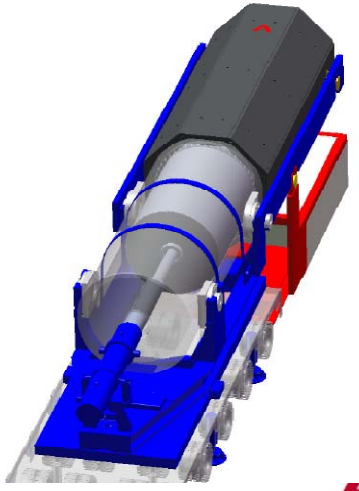
Main Innovations of the TN NOVA™

- 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

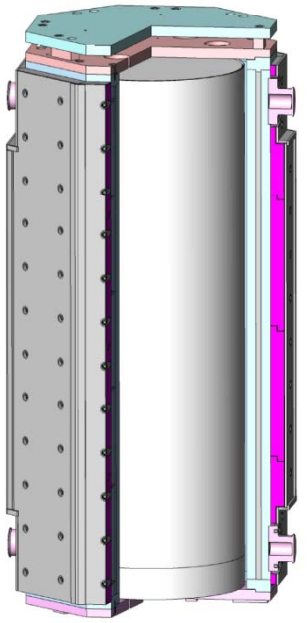


TN®NOVA Advantages

The result of an intensive innovation process

TN®NOVA

- **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)**

Conclusion

- **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**