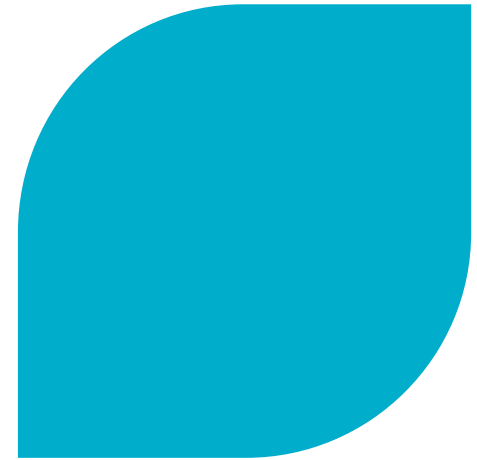


Additional assessment of beyond design basis accidents in spent fuel dry storage



Herve Issard, Laurent Milet

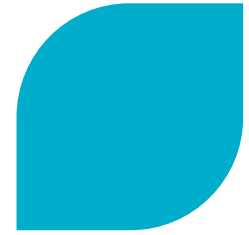
IAEA TM 52204 - Design Extension Conditions for Storage Facilities for Power Reactor Spent Fuel

27 June to 1 July 2016 at the IAEA's Headquarters in Vienna

AREVA TN



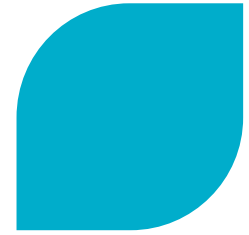
Additional assessment of beyond design basis accidents in spent fuel dry storage



► Summary

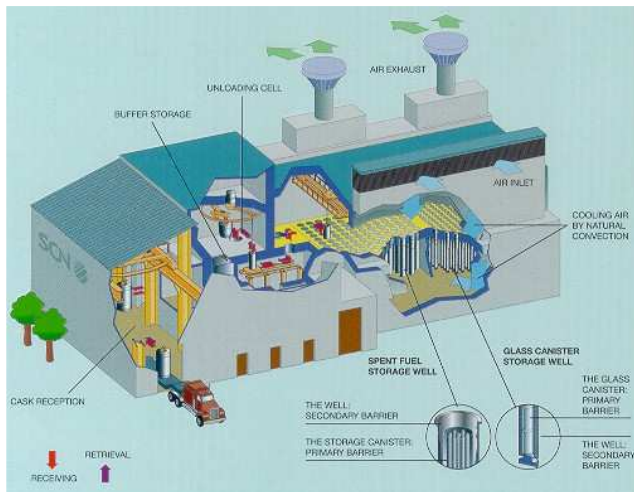
- ◆ Dry storage solutions
- ◆ Context changed since the Fukushima earthquake
- ◆ Definition of design extension conditions
- ◆ Ability of storage systems to withstand severe accidents
- ◆ Knowledge update & Potential risks, extreme scenarios or conditions
- ◆ Emergency arrangements in France & conclusions

Spent fuel dry storage solutions

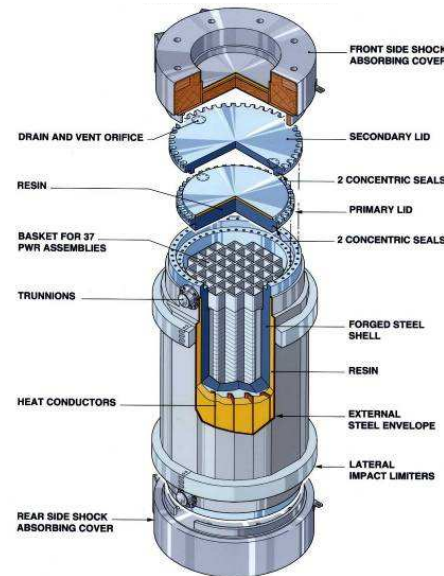


- ▶ **Interim storage of used fuel, basic principle**
 - ◆ Limited time, 30 to 40 years
 - ◆ Allow for used fuel cooling
- ▶ **Different systems to store used fuel designed by AREVA**
 - ◆ In use for decades
 - ◆ Safety records : experience covering more than 30 years

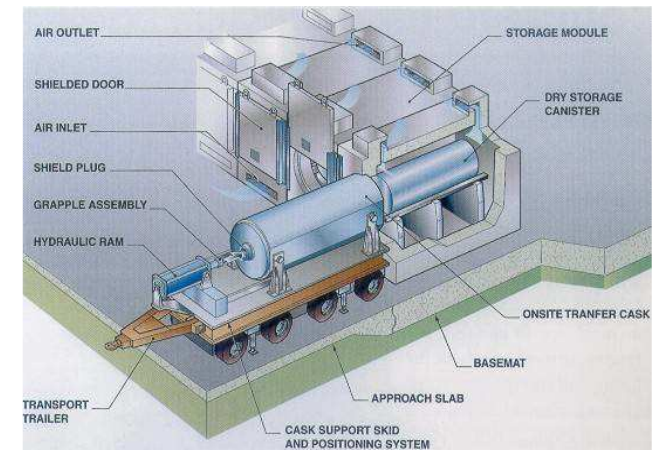
Vaults (Cascad type)



Metal casks (TN[®]24)



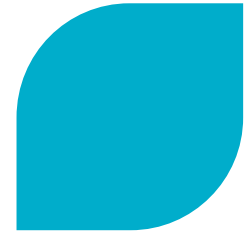
Canister based systems (Nuhoms[®])



AREVA TN

Design Extension Conditions for Storage Facilities for Power Reactor Spent Fuel

Additional assessment of beyond design basis accidents in spent fuel dry storage



► Context changed since the Fukushima earthquake and subsequent tsunami

- ◆ In response to such extreme events or accidents, considerations are made to develop scenarios and to propose mitigation measures for used fuel storage facilities within and beyond the current design basis
- ◆ IAEA Nuclear safety : working group on revision of document SSG 15 on safety of dry storage
- ◆ Actually, Fukushima accident shows that in dry storage facilities early or large releases in extreme accidents can be excluded

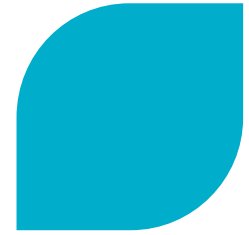
IAEA Safety Standards
for protecting people and the environment

Storage of
Spent Nuclear Fuel

Specific Safety Guide
No. SSG-15



Additional assessment of beyond design basis accidents in spent fuel dry storage



► Definition of design extension conditions

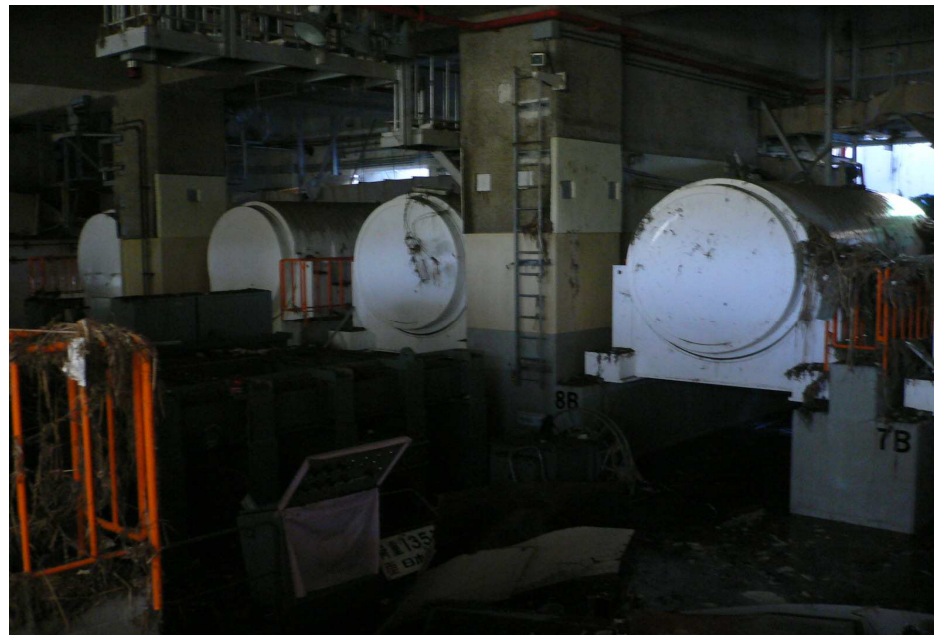
- ◆ Design extension conditions : a set of hypotheses and considerations for safety base addressing potential risks beyond existing scenarios.
- ◆ New “extended accident” scenarios are identified by member states which may potentially lead to significant release of radioactive material and to severe radiation exposures.
- ◆ Internal hazards are problems associated with human actions (errors or malevolent actions) = not treated in the design extension conditions.
- ◆ External hazards: aircraft crash, fire, earthquake, flooding, cask burial, cask tip-over...

Ability of storage systems to withstand severe accidents



► Casks stored at the Fukushima Storage Building

- ◆ The storage systems have demonstrated their ability to withstand severe accidents. In particular, the 9 TN[®]24 casks stored at the Fukushima-Daiichi Storage Building (with 408 BWR used nuclear fuel assemblies) endured the tsunami in March 2011.



AREVA TN

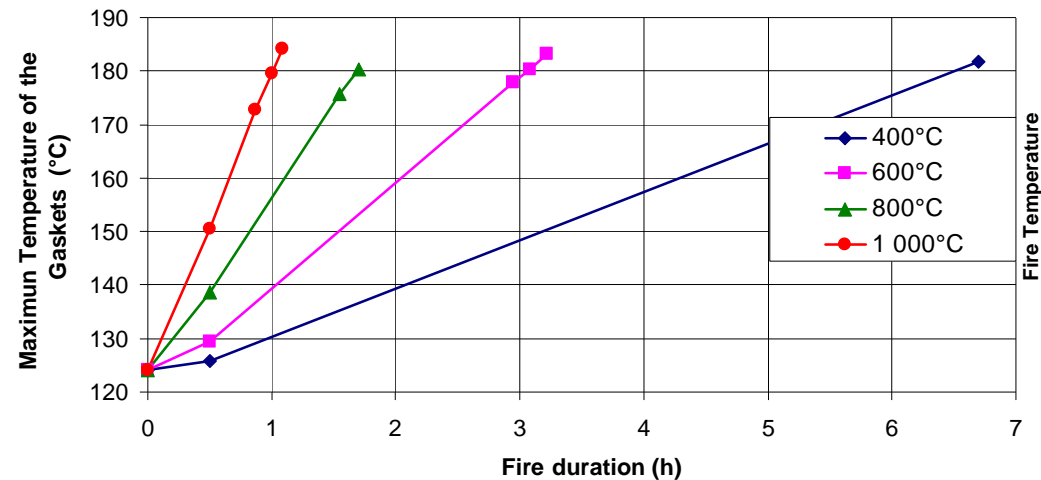
Design Extension Conditions for Storage Facilities for Power
Reactor Spent Fuel

Ability of storage systems to withstand severe accidents

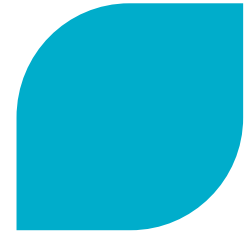


► Casks can resist to regulatory tests applicable to dry storage but also to potentially more severe tests.

- ◆ For example thermal performance was checked in severe conditions, component temperatures are kept in the acceptable range
- ◆ Example TN28VT cask gasket temperature



Ability of storage systems to withstand severe accidents



- ▶ **Casks can resist to regulatory tests applicable to dry storage but also to potentially more severe tests.**
 - ◆ **To protect the cask closure system during the aircraft crash the TN[®]24 design includes a special lid resisting to impact**



AREVA TN

**Design Extension Conditions for Storage Facilities for Power
Reactor Spent Fuel**

Additional assessment of beyond design basis accidents in spent fuel dry storage



► Knowledge update & Potential risks, extreme scenarios or conditions

- ◆ Reassessment of dry storage installations: in the USA and other member states, the dry storage systems like NUHOMS® are expected to be stored at reactor sites for period longer than the initial licensed period of 20 years due to delay in final disposal solution, and consequently are more exposed to the risk of extreme events.
- ◆ Therefore, blockage of air inlet and outlet cooling vents due to debris accumulation during flood, rain, mud or dust during longer storage period, were also reassessed for NUHOMS® system.
- ◆ Similar reassessments for metal casks

Knowledge update & Potential risks extreme scenarios or conditions



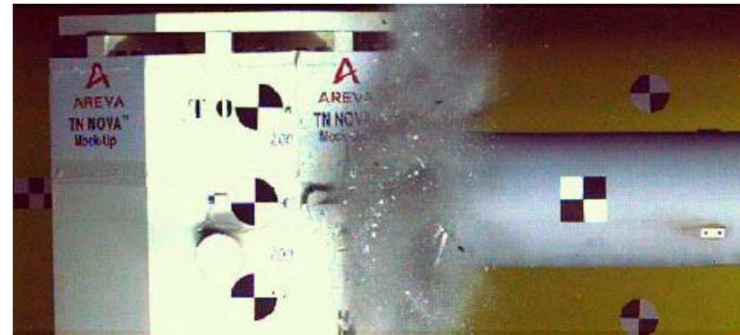
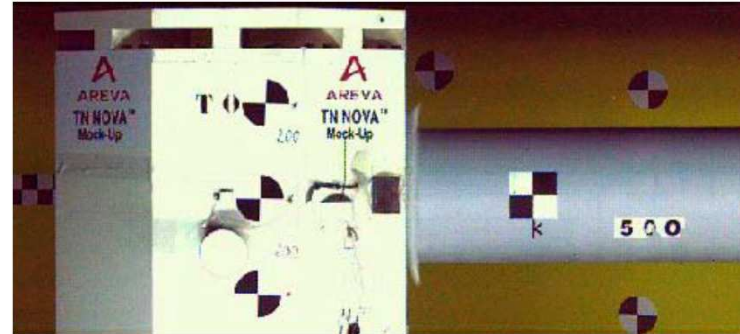
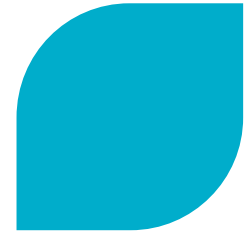
- ▶ **Dry storage systems = highly resistant system in severe accidents**
 - ◆ **Resist to Earthquakes (important safety functions maintained):**
 - March 2011 east Japan earthquake and tsunami
 - August 2011 Central Virginia USA earthquake
 - No release
 - ◆ **Extreme conditions: resistance of heavy casks to high external pressure: checked through testing**
 - ◆ **Aircraft crash (F16 type) testing achieved successfully on cask specimen. TN Nova™ design.**



AREVA TN

Design Extension Conditions for Storage Facilities for Power
Reactor Spent Fuel

Knowledge update & Potential risks extreme scenarios or conditions



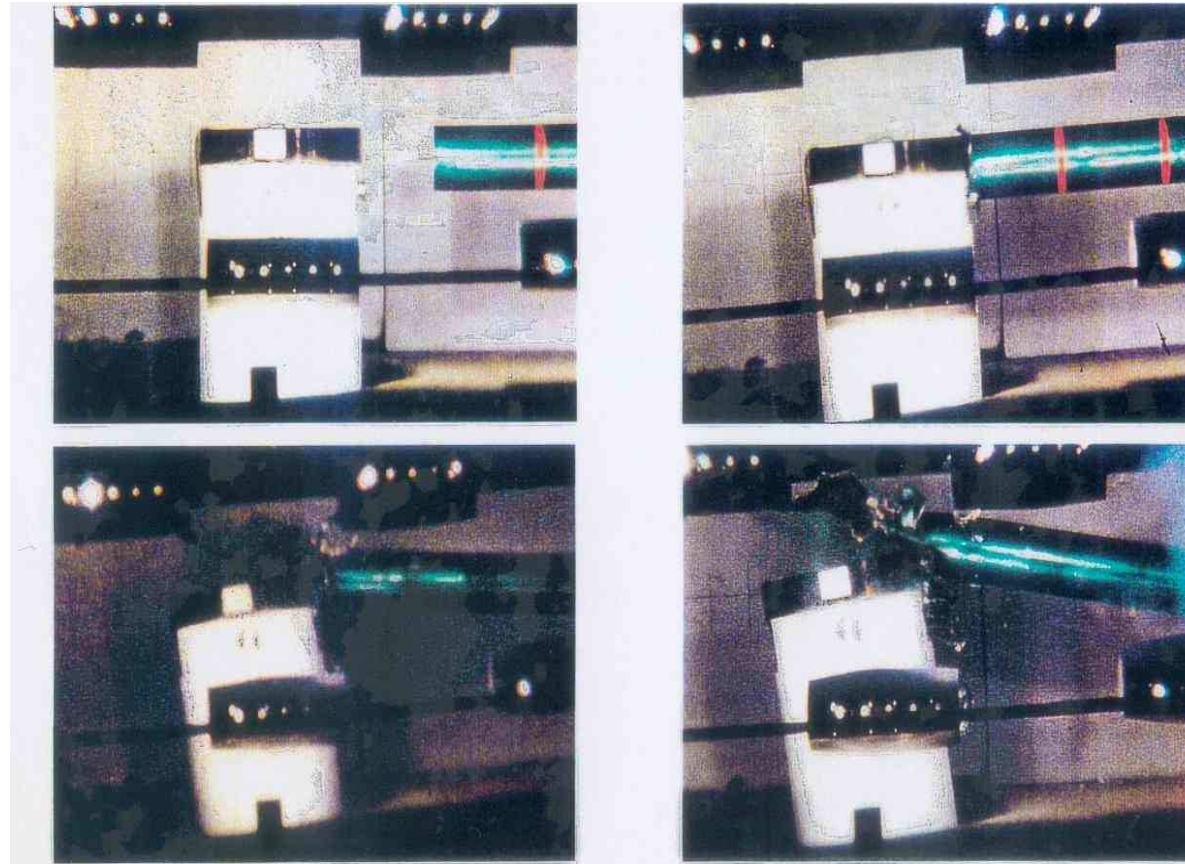
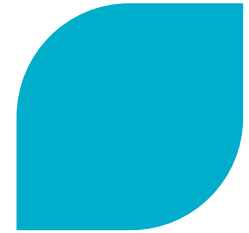
AREVA TN

TN NOVA™ impact test program

Design Extension Conditions for Storage Facilities for Power
Reactor Spent Fuel



Knowledge update & Potential risks extreme scenarios or conditions



Impact test program has shown that the TN™ 24D cask can withstand an aircraft crash (F16 Fighter)

AREVA TN

Design Extension Conditions for Storage Facilities for Power
Reactor Spent Fuel

AREVA
forward-looking energy

Knowledge update & Potential risks extreme scenarios or conditions



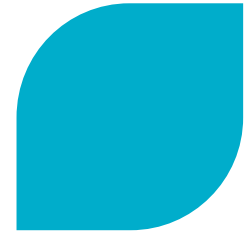
- ▶ **Seismic event**
 - ◆ Vertical seismic response spectra
 - ◆ Horizontal seismic response spectra
- ▶ **Criteria :**
 - ◆ No tip over
 - ◆ No « domino » effect
- ▶ **Result of evaluation : satisfactory**

Knowledge update & Potential risks extreme scenarios or conditions



- ▶ **Fire accident : 600 ° C during 1 hour**
- ▶ **Burying conditions to evaluate consequences of the building collapse**
 - ◆ **Criteria :**
 - ◆ **respect of temperature criteria on gasket, fuel rod**
 - ◆ **input data for shielding analysis**
- ▶ **Result of evaluation : satisfactory**

Additional assessment of beyond design basis accidents in spent fuel dry storage



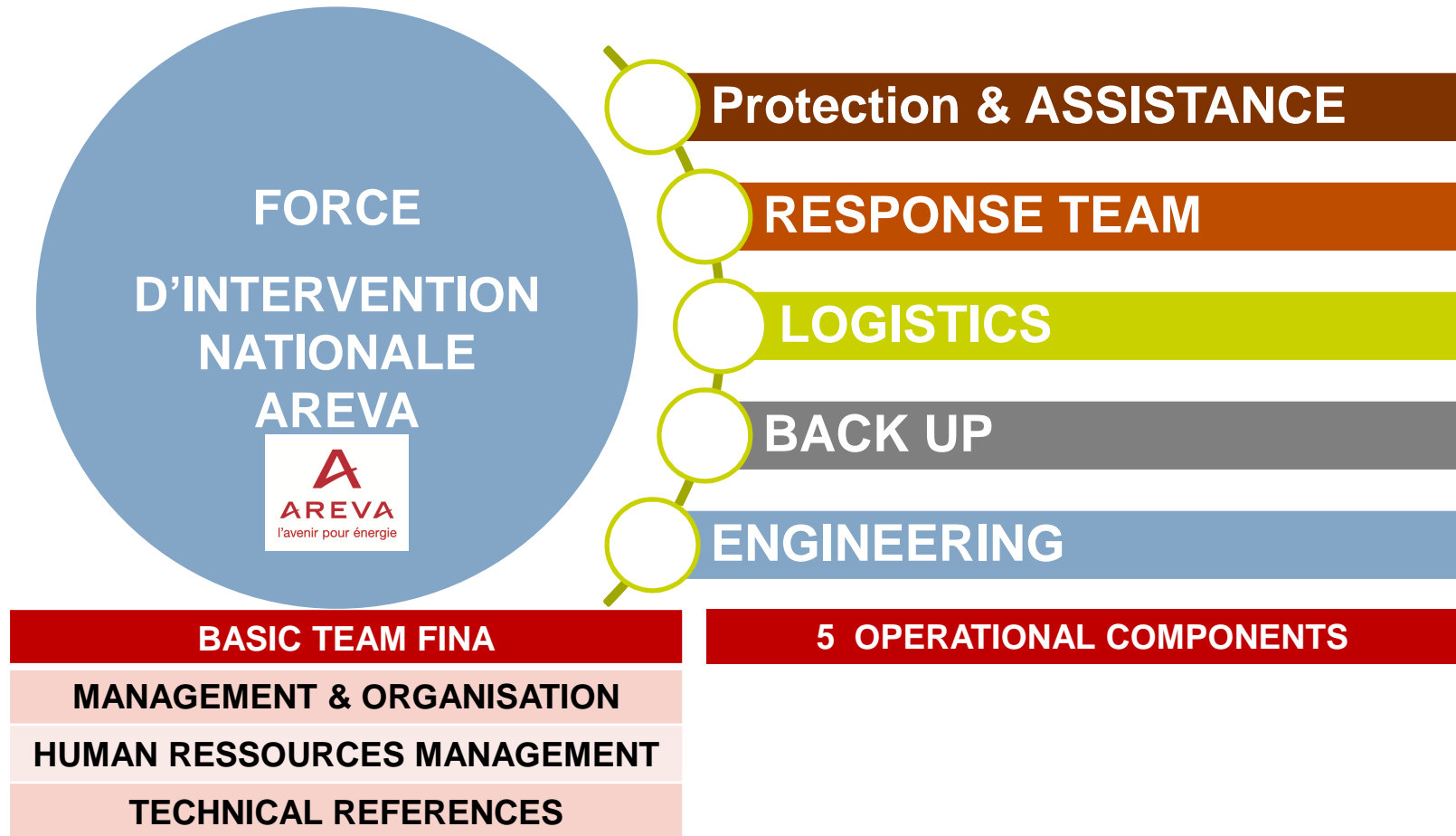
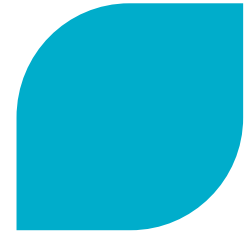
▶ Emergency arrangements in France & conclusions

- ◆ FINA response system : AREVA National Response Force
- ◆ For transport and consequently for post storage transport, an update of operating procedures and contingency and emergency arrangements was developed in France in the event of a transport accident.
- ◆ The FINA organization is incorporated into AREVA's general emergency management organization and is subject to regular drills. It is operational 24/7.

▶ Training – exercise :

- ◆ 2 days / once a year at least

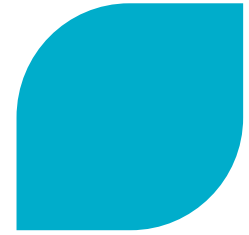
FINA Operational structure



AREVA TN

Design Extension Conditions for Storage Facilities for Power
Reactor Spent Fuel





Thank you for your attention

AREVA TN

**Design Extension Conditions for Storage Facilities for Power
Reactor Spent Fuel**

