ADDING WET TRANSPORT CAPABILITIES TO A DRY TRANSPORT CASK
THE EXAMPLE OF THE TN 13/2

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WHY ADD WET TRANSPORT CAPABILITY TO A DRY TRANSPORT CASK ?

- To cool more efficiently the fuel pins so the fuel assemblies can be safely reloaded in reactor cores.

- To reduce preparation times of the packages prior to shipment (neither draining nore drying of the cask cavity).

THE TN 13/2 SPENT FUEL CASK

- In service since 1983

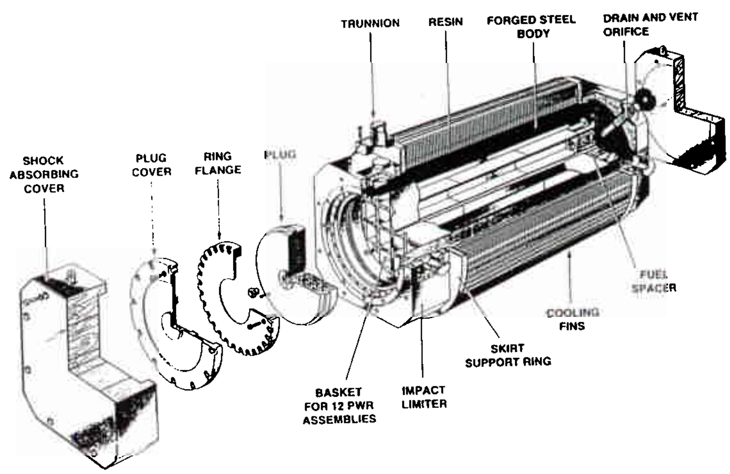
- 8 casks operated

- Shippement by road and rail of spent fuel from French and German 1300 MWe NPPs to the La Hague Reprocessing Plant

- About 100 shipments/year

- Cavity dimensions :
  - diameter : 1.2 m
  - length : 5.15 m

- Empty weight : 99 tons



DRY VERSION CAPABILITIES

- Up to12 PWR spent fuel assemblies

- Maximum heat load : 110 kW

- Cavity filled with dry air or inert gas at sub-atmospheric pressure

- Loaded weight : 113.5 tons

- Use : shipment of short cooled high burn-up fuel to Reprocessing Plant

WET VERSION CAPABILITIES

- Up to 10 PWR spent fuel assemblies

- Maximum heat load : 40 kW

- Cavity filled partially with water completed by air or nitrogen

- Loaded weight : 113.5 tons

- Use : fuel movements between reactors of Nuclear Power Plants

SAFETY ASPECTS OF ADDING WET CAPABILITIES

Thermal analysis

- Much more efficient heat transfer system within the cask cavity :
  - radiative heat transfer replaced by convection heat transfer in water ,
  - average temperature of the basket ≈ average temperature of the water.
- Originally designed for 110 kW, cask body and baskets do not need design changes for a heat power of 40 kW or less.
- Maximum allowable level of water is determided by taking into account thermal expansion of water and pressure rise of the gas volume at maximum conditions of temperature i.e. temperature reached after the I.A.E.A. 800°C thermal test (accidental conditions of transport).

Radiolysis analysis

- Water + radiation = H_2 and O_2 production = potential flammable risk.
- Theorical gas production rate (G_{H2}) for pure water (0.45 H_2/100eV) overestimates gas production in transport casks. In fact, taking advantage of the chemical complexity of the medium, effective G_{H2} value is closer to 0.005 than 0.45.
- Using results of some experiments made by CEA and EDF and having also initiated a specific rodiochemical modelling of the TN 13/2 using methods described by Walkers (1) the following G_{H2} values have been determined :
  - 0.0055 H_2/100eV in normal conditions of transport
  - 0.040 H_2/100eV in accidental conditions of transport
- At these rates, the TN 13/2 cavity gas remains well outside flammable mixture regimes for an acceptable transport duration (about 1 month).

Mechanical resistance

- Water + heating and shock = pressure increase = potential mechanical risks for confinement system
- Pressure in water when subjected to a deceleration : $P = \rho.\gamma.h$
  where P = pressure, ρ = density, γ = deceleration, h = height of the water
  This has been validated by a 9m drop test
- With the specified thermal power of the irradiated nuclear fuel and when subjecting the cask to the 800°C thermal test, the resulting pressure is less than the cask design value.

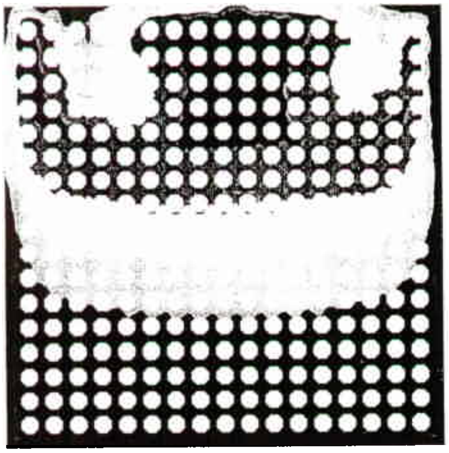
Confinement

- Release = gas release + liquide release
- Fuel pin ruptures occuring during transport of wet casks assumed to be :
  - 1.5% for normal condition of transport,
  - 100% for accidental condition of transport.
- The 9m drop test performed validated water and gas tightness of the TN 13/2
- Analysis and test results show that the cask complies with activity release limits.

Criticality

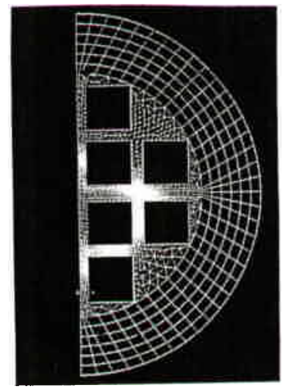
- Water penetration is always considered for dry transport casks, hence, no additionnal criticality analysis is needed.

Temperature map within a logement



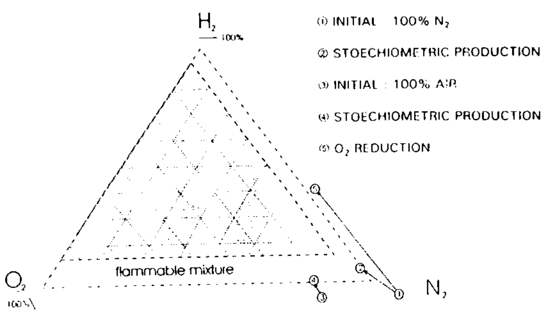
θmax - θmax ≈ 6°C

Temperature map within the cask and the basket in Normal Conditions of Transport

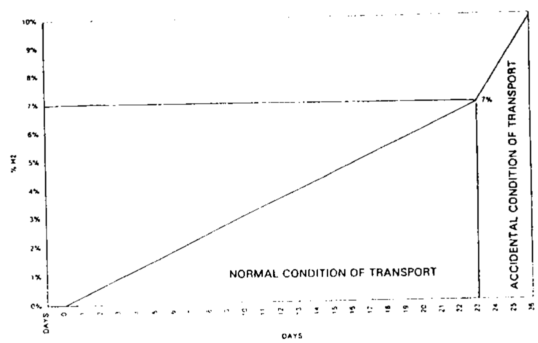


θmax - θmax ≈ 50°C

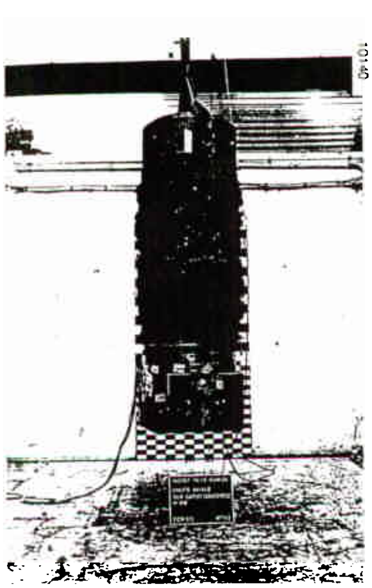
Flammability of gas mixture H_2-O_2-N_2



H_2 production in TN-13/2



Drop test cask, scale 1/3



Inner loading of the test cask

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