Cementitious materials/components for HLW/ILW repository : priorities of the future R&D in the French context

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Andra R&D Division

Concepts

Cigéo project

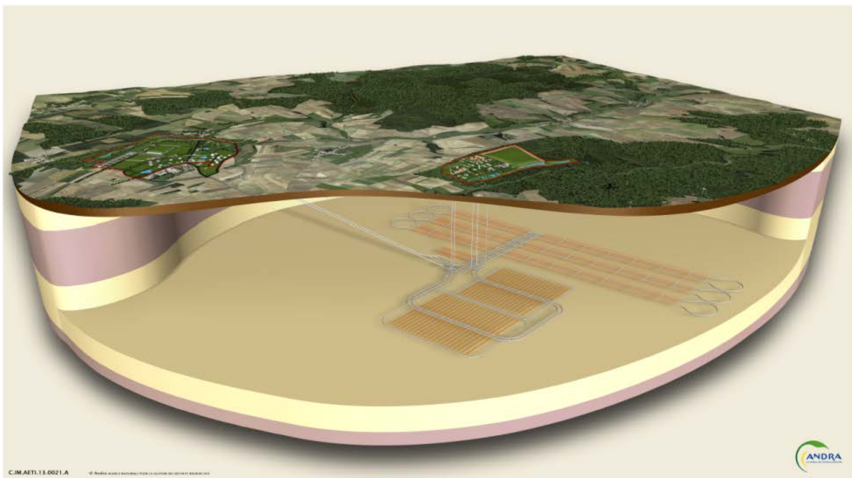
- ☐ Operating period 2025/~2140
- ☐ HLW cells :*vitrified wastes*
- ☐ ILW cells : *metallic wastes, bituminised wastes, salts, etc*
- ☐ Length of underground facilities ~ galleries 78 km ; cells/vaults 197 km
- ☐ Total excavated volume : 9,2 millions m^3
- *Half of the total excavated volume will be filled with concrete*

Cigéo project *milestones*

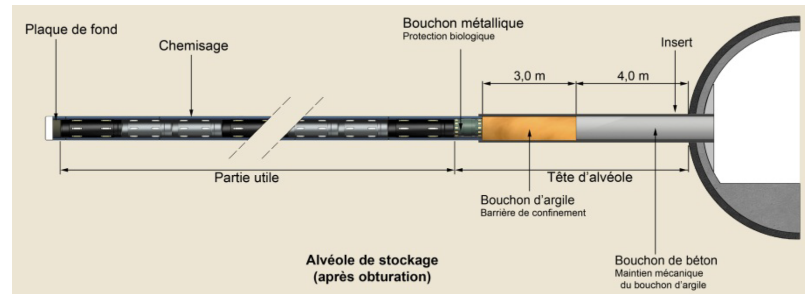
- ☐ 2005/2006 : feasibility report and planning act
- ☐ 2015 : review of the license application for the construction of the geological disposal
- ☐ 2025 : begining of the operating phase

HLW and ILW French Concepts

- Concrete use in sedimentary host rock conditions
  - *Structures : shafts, access ramps, galleries*
  - *ILWaste packages and disposal cells*
  - *Walls of plugs/seals*

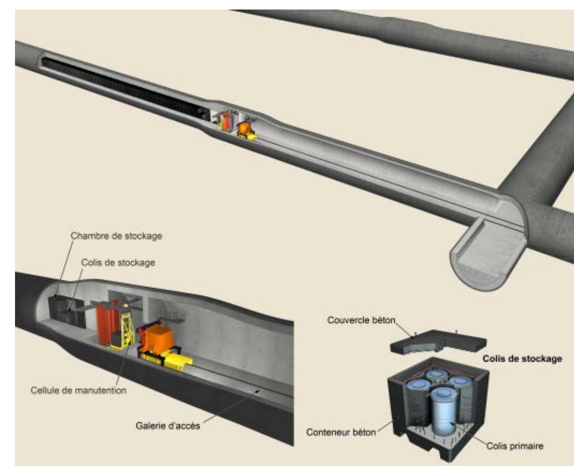


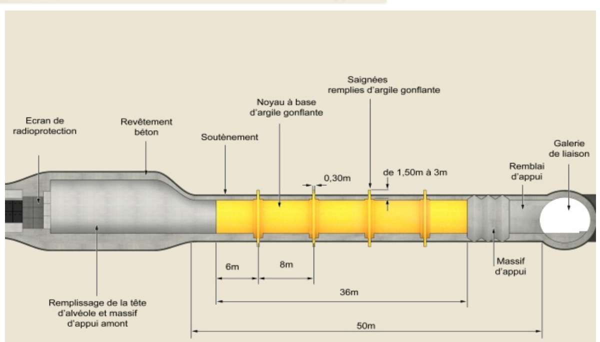
Global overview



High Level Wastes

Intermediate Level Wastes





ILW vault seal

Cigéo requirements and functions

- Operating phase and retrieviability – short term (up to 120/150 y.)
  - *To guaranty safety*
    - To ensure mechanical stability/durability (structures, waste packages)
- Post closure, long term
  - *To limit water flow within the repository*
    - To limit chemical degradations
    - To protect wastes and thus to limit radionuclide release
  - *To immobilize RN within the repository*
    - To enhance radionuclide retention through sorption and solubility limitation
  - *To preserve performance of other safety components*
    - To limit clay host rock degradation

Short term evolution : main processes

Initial State

- ☐ Specifications, civil engineering background, normalisation
- ☐ Key points : Alkali-Silica Reaction, Internal Sulphate Reaction

Short term evolution (operating phase)

- ☐ Atmospheric carbonation
  - + *Recent studies (still on going) to validate, with T and HR, the evolution of carbonation*
  - + *Modification of the physico-chemical properties vs steel corrosion*

- ☐ Steel corrosion
  - + *Corrosion rate in a passive state*
  - + *Lack of knowledge*
    - » Mechanical properties of the corrosion product layer
    - » Corrosion rate in carbonated concretes

Medium and long term evolution: main processes (1/2)

Long term Physico-Chemical evolutions

- To fulfill the requirements according to repository conditions…
  - + *Chemical evolutions at interfaces with swelling clay*
  - + *Impact of mechanical constraints as well as chemical conditions imposed by the clay host rock (structures, vaults)*
  - + *Chemical evolution influenced by wastes (T, agressive species) and waste degradation (RN behaviour)*

  - ➢ ***Coupled chemical/transfer evolution***
  - ➢ ***Coupled chemical/mechanical evolution***

- Background : single phenomena/materials studied for years in national programs
  - + *Concretes : enough to describe « classical » concrete chemical evolution with regards to the main chemical degradations (i.e.* Hydrolysis/decalcification, Sulphate attack / DEF, Carbonation *)*
  - + *Low hydration Heat/low pH cement : reference formulation (ternary blends)*
  - + *RN : chemistry in alkaline environment (solubility limits, sorption on cement hydrates)*

Medium and long term evolution : main processes (2/2)

- R&D priorities on Long Term Physico-Chemical evolutions
  - ☐ Both sides of the Concrete/Clay interface
    - + *Low Hydration Heat/Low pH cements chemical evolution*
      - » Phenomenology (*chemical evolution vs physical properties*)
      - » Consistency/exhaustivity of some TdB *vs* C-S-H, M-S-H
    - + *Coupled chemical/transfer phenomena on both sides, including coupled chemical reactions at cement host rock interface*
      - » Dissolution/precipitation
      - » Neoformation (zeolites ?)
    - + *Coupled chemical /physical evolution*
      - » Opening/clogging porosity
      - » Cracking
      - » Cement/clay bonding
  - ☐ RN chemical behaviour with regards to specific conditions
    - + *Chemical/physical evolution at the interfaces*
    - + *Impact of complexing agent*

✓ ***License application context : margins for safety, conception, retrieviability***

…Thank You for your attention