



***French Experience in Nuclear Waste  
Management***

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# ***Act No.75-633 of July 15, 1975***

- ▶ ***Waste producers are responsible for the waste, as long as it is not stored, processed or eliminated in conditions consistent with the law.***

# Radioactive Waste Classification

**Short lived waste**  
(period of main nuclides < 30 years)

**Long lived waste**

Very low level	<b>TFA</b>	Operating Morvilliers Centre	<i>Mining Residue</i>
Low level	<b>A</b>	Operating Aube Centre	Under development (near surface) (graphite, radium bearing)
Intermediate level			<b>B</b>
High level	<b>C</b>	Under development Law December 30, 1991	

# Activity Levels (orders of magnitude)

Very low level

0 to 100 bq/g



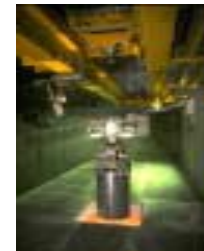
Low level

100 to 100,000 bq/g  
max alpha: 3,700 bq/g



Intermediate  
Level

100,000 to 100,000,000 bq/g



High level

10,000,000,000 bq/g

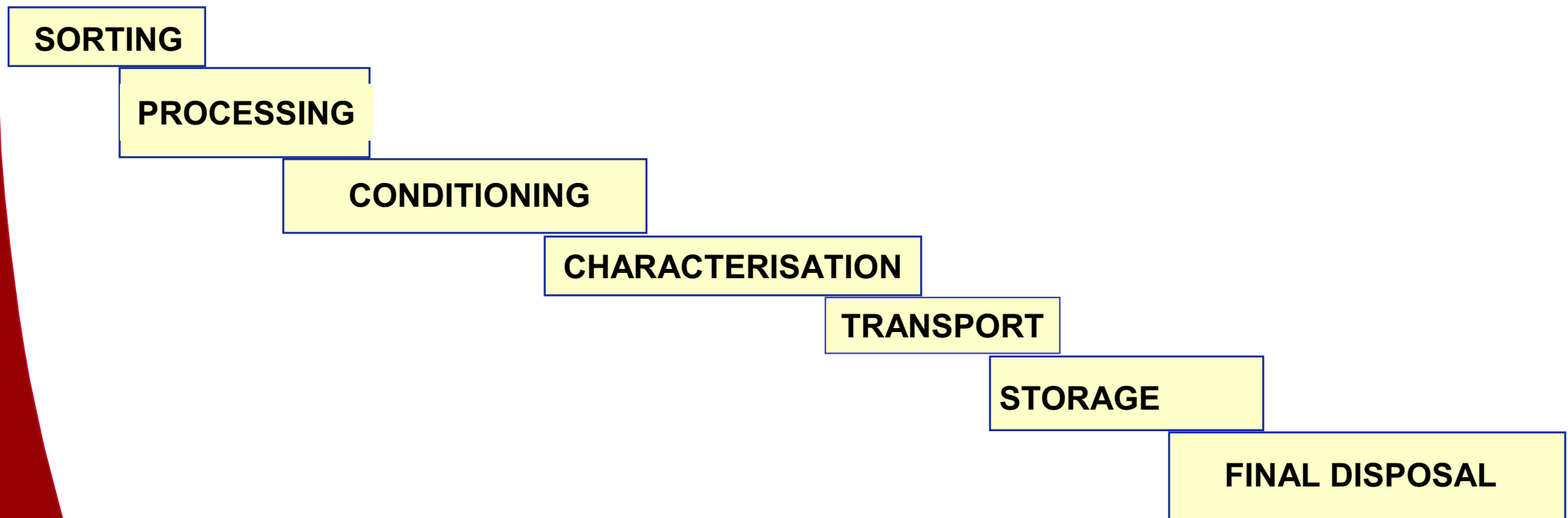


# **Order of Magnitude**

**(waste generated and to be generated from existing facilities)**

<b>Category</b>	<b>Volume</b>	
<b>VLL</b>	<b>1 to 2,000,000 m<sup>3</sup></b>	<b>Non conditioned waste (excluding mining waste: 52 Mt)</b>
<b>LIL SL (Cat. A)</b>	<b>1,300,000 m<sup>3</sup></b>	<b>Disposed conditioned waste (Manche Centre, Aube Centre)</b>
<b>LL LL</b>		
<ul style="list-style-type: none"> <li>▪ <b>Graphite waste</b></li> <li>▪ <b>Radium bearing waste</b></li> </ul>	<p style="text-align: center;"><b>14,000 m<sup>3</sup></b></p> <p style="text-align: center;"><b>&gt; 100,000 m<sup>3</sup></b></p>	<p><b>Non conditioned waste</b></p> <p><b>Non conditioned waste (historical waste)</b></p>
<b>IL LL (Cat. B)</b>	<b>60,000 m<sup>3</sup></b>	<b>Conditioned waste</b>
<b>HL (Cat. C)</b>	<b>5,000 m<sup>3</sup></b>	<b>Conditioned waste</b>
<b>+ Spent fuel</b>	<b>3,500 t</b>	<b>Depending on the scenario</b>

# *Radioactive waste management*



# ***The law of 12/30/91***

- ▶ ***Stipulates the conditions by which radioactive waste are to be managed:***
- ▶ ***CATEGORY A = Surface disposal***
- ▶ ***CATEGORIES B and C = Storage pending the results of current research on:***
  - ◆ ***reversible or irreversible disposal in deep geological formations: Construction of underground laboratories,***
  - ◆ ***the conditioning of waste for long-term storage,***
  - ◆ ***the separation and transmutation of long-lived radioactive elements into short-lived elements.***

## ▶ *The decree provides for:*

- ◆ *The elaboration of "waste studies" designed to prepare an inventory of the facilities and optimise the management of waste at a site.*

- ◆ *Behaviour studies, notably the definition:*

- *"Waste zoning" distinguishing:*

- *"nuclear waste zones",*
- *"conventional waste zones",*

*Independent of all measurements, this zoning is based on the analysis of the design, operation and history of the facility.*

- *Adapted measurements during waste transport*
- *Waste elimination chains*
- *Waste assessments*

# ***Optimisation of the cycle of waste in nuclear installations in operation (cont'd)***

## **▶ SORTING AND ORIENTATION TO THE APPROPRIATE FACILITIES**

- ◆ *recycling***
- ◆ *processing***
- ◆ *packaging.***

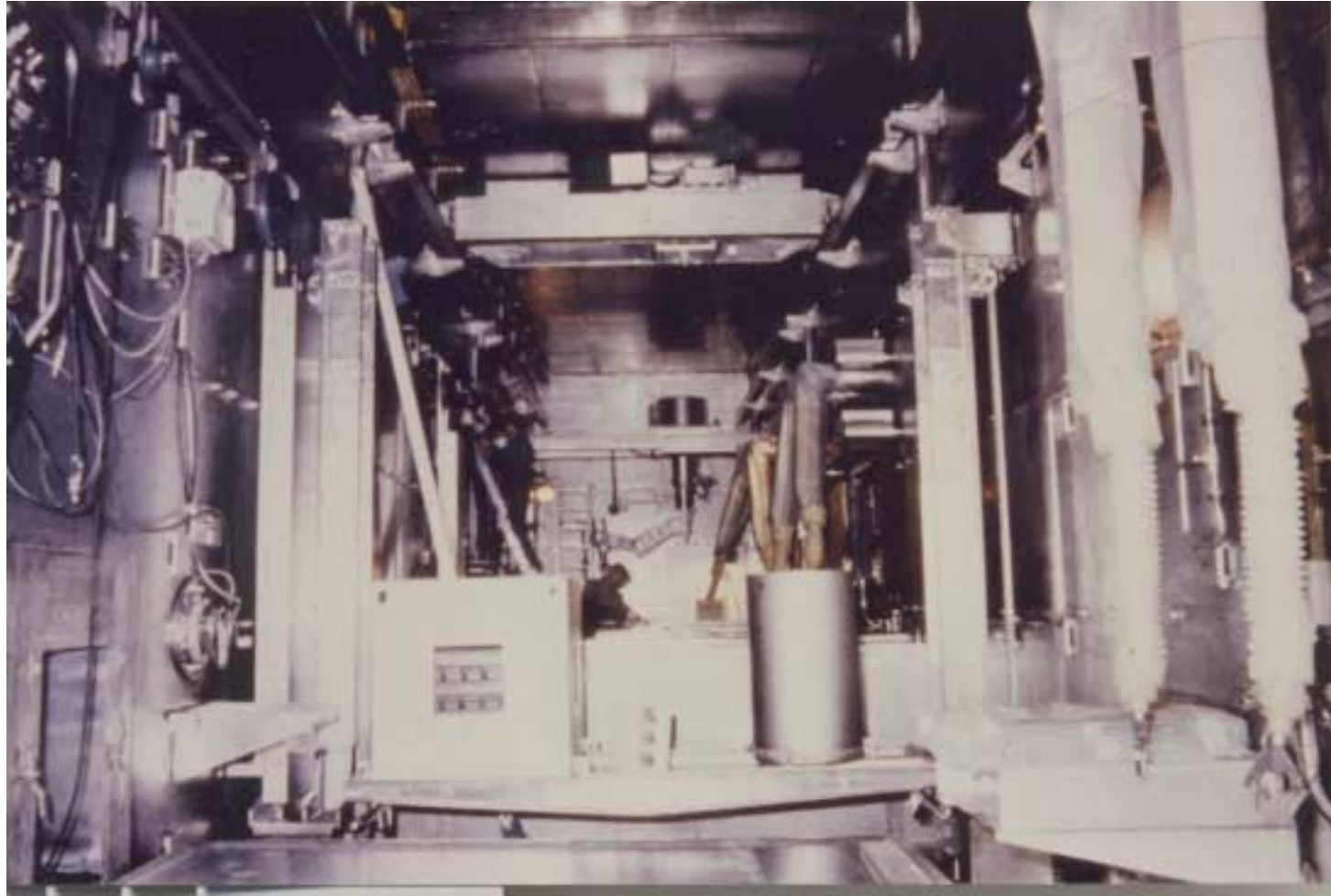
## **▶ IMPLEMENTATION OF QUALITY CONTROLS ENSURING TRACEABILITY.**

# Processing of solid wastes

## ▶ DECONTAMINATION

- ◆ Objective: *Declassify solid wastes (from type B to type A for example or very low-level radioactive waste).*
- ◆ Techniques:
  - *chemical processing by washing or spraying with reagents,*
  - *electrolytic, ultrasound processes,*
  - *mechanical abrasion techniques,*
  - *washing (smocks, protective clothes),*
  - *strippable paint, etc.*

# **COGEMA La Hague AD1 Decontamination Cell**



# AD2 – Decontamination cell facade



## ▶ VOLUME REDUCTION

◆ Objective: *Optimisation of transport and storage costs.*

◆ Techniques:

- *incineration*
- *compacting*
- *fusion of metals*
- *cutting - disassembly.*

# ***Waste incineration Important safety aspects***

- ▶ ***Prior sorting of waste under confinement.***
- ▶ ***Confinement during waste introduction and extraction of ashes.***
- ▶ ***Fractioning when loading wastes.***
- ▶ ***Vacuum holding and control in all equipment - safeguarded equipment - operating 1 / 2.***
- ▶ ***Absolute filtration of extraction gases prior to release.***
- ▶ ***Control at the stack.***

# Processing of liquid effluents

## ▶ SEPARATION

- ◆ Objective: Isolation of dissolved or suspended radioactive isotopes.
- ◆ Techniques:
  - decantation - precipitation
  - Filtration, microfiltration, ultrafiltration, reverse osmosis
  - adsorption

## ▶ VOLUME REDUCTION

- ◆ Objective: Optimisation of storage costs
- ◆ Techniques:
  - evaporation
  - incineration
  - ISOFLASH drying calcination
  - selective adsorption

# Waste conditioning

## ▶ Objective:

- ◆ *To condition the waste in solid form by incorporating it in a matrix, in order to obtain a stable product which meets the acceptability criteria of waste storage or disposal centres.*

## ▶ Type A and B waste.

- ◆ *Encapsulation in a hydraulic binder (cement).*
- ◆ *Encapsulation in a thermosetting resin (epoxy or polyester).*
- ◆ *Encapsulation in glass.*

## ▶ Type C waste: Vitrification

# *Epoxy Encapsulation – SETH 200*



# ***MERCURE machine - EDF***



# Characterisation of waste packages

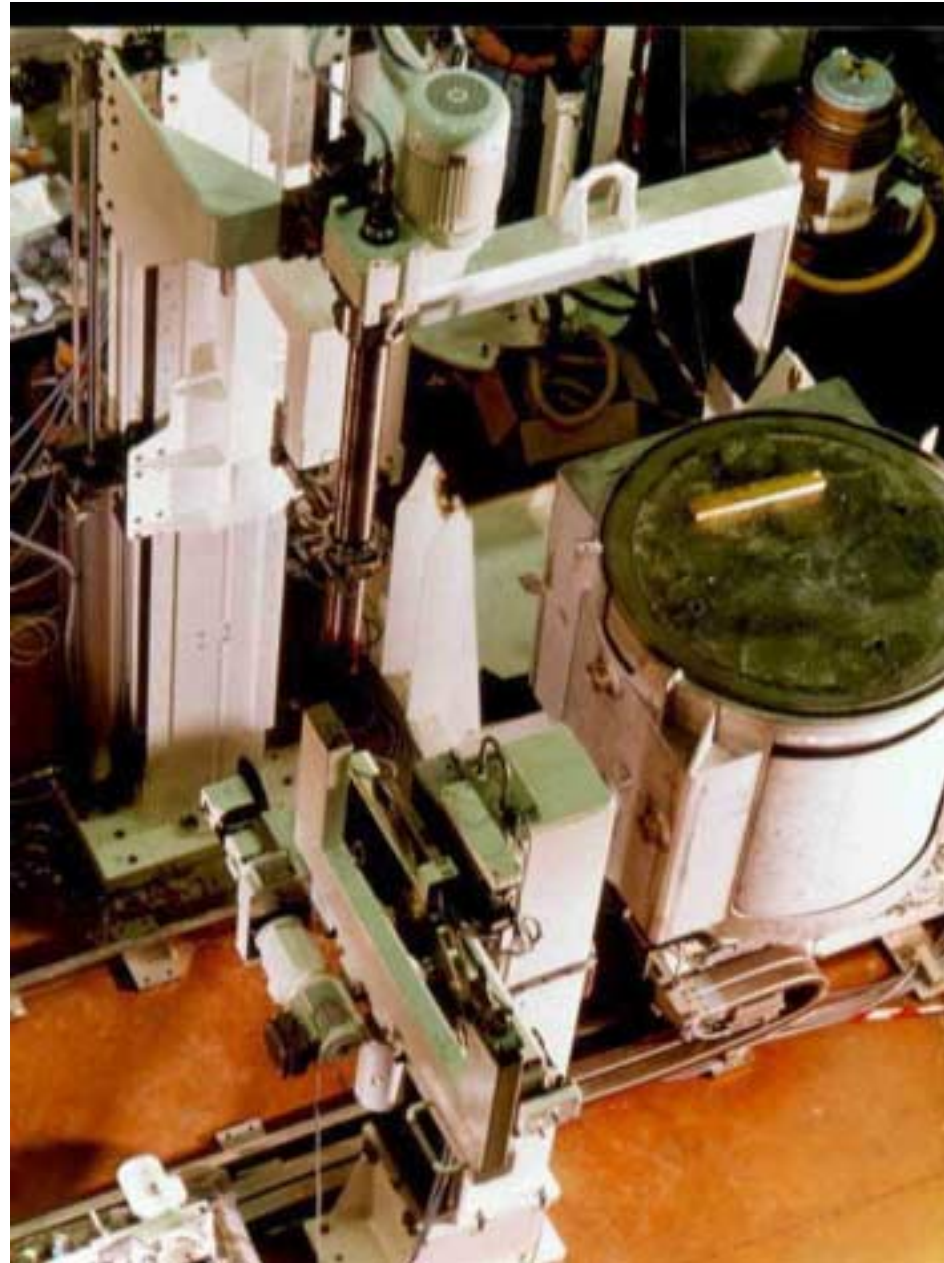
## ▶ Objective:

- ◆ *To ensure that the processing and packaging operations have generated packages that meet the acceptability criteria of Waste Storage or disposal.*

## ▶ Means :

- ◆ *By using cells and approved testing laboratories on prototype packages and by sampling packages shipped to the storage or disposal.*

# ALCESTE



# ***The transport of radioactive waste***

- ▶ ***The ADR decree stipulates the conditions required for packages and tanks to offset the risks of fall, fire, accident, aggression, etc.***
- ▶ ***The ADR indicates the obligations in terms of radiological protection, and the limitation of contamination and dose equivalent rate.***

# Storage of radioactive waste

## ▶ **OBJECTIVE:**

- ◆ *Temporary isolation of B and C type waste, packaged pending a definitive storage solution.*
- ◆ *Placement of waste packages in compartments or storage pits - Reversibility of the storage.*
- ◆ *Package management and handling means.*
- ◆ *If necessary (C type), the containers are cooled in ventilated storage pits.*
- ◆ *Studies are pending on very long-term storage facilities.*

# *EDS – Drum and gripper assembly*



# *EDS – Maintenance facility*



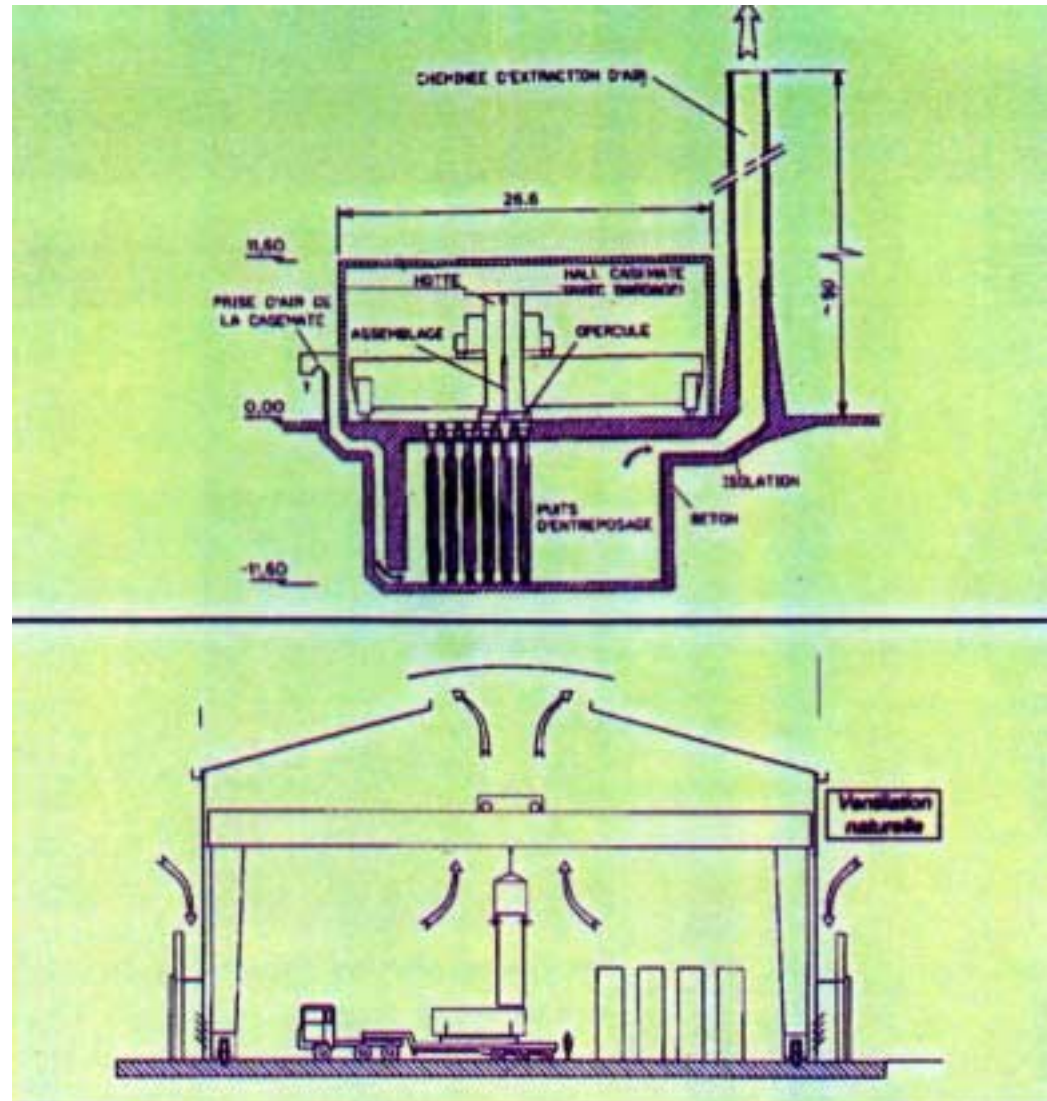
# Concrete shell storage



# CEA/Cadarache - CASCADE



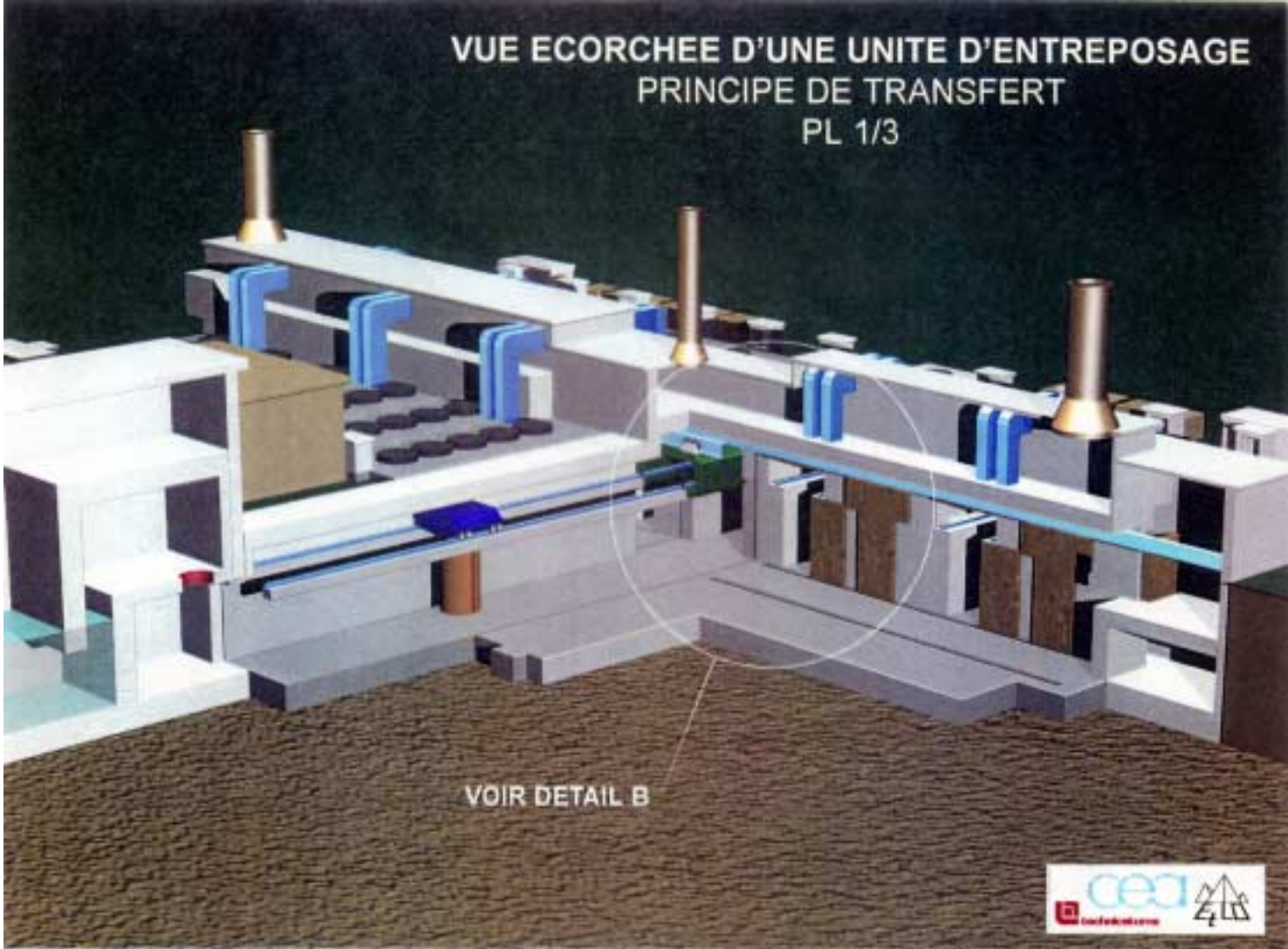
# Storage



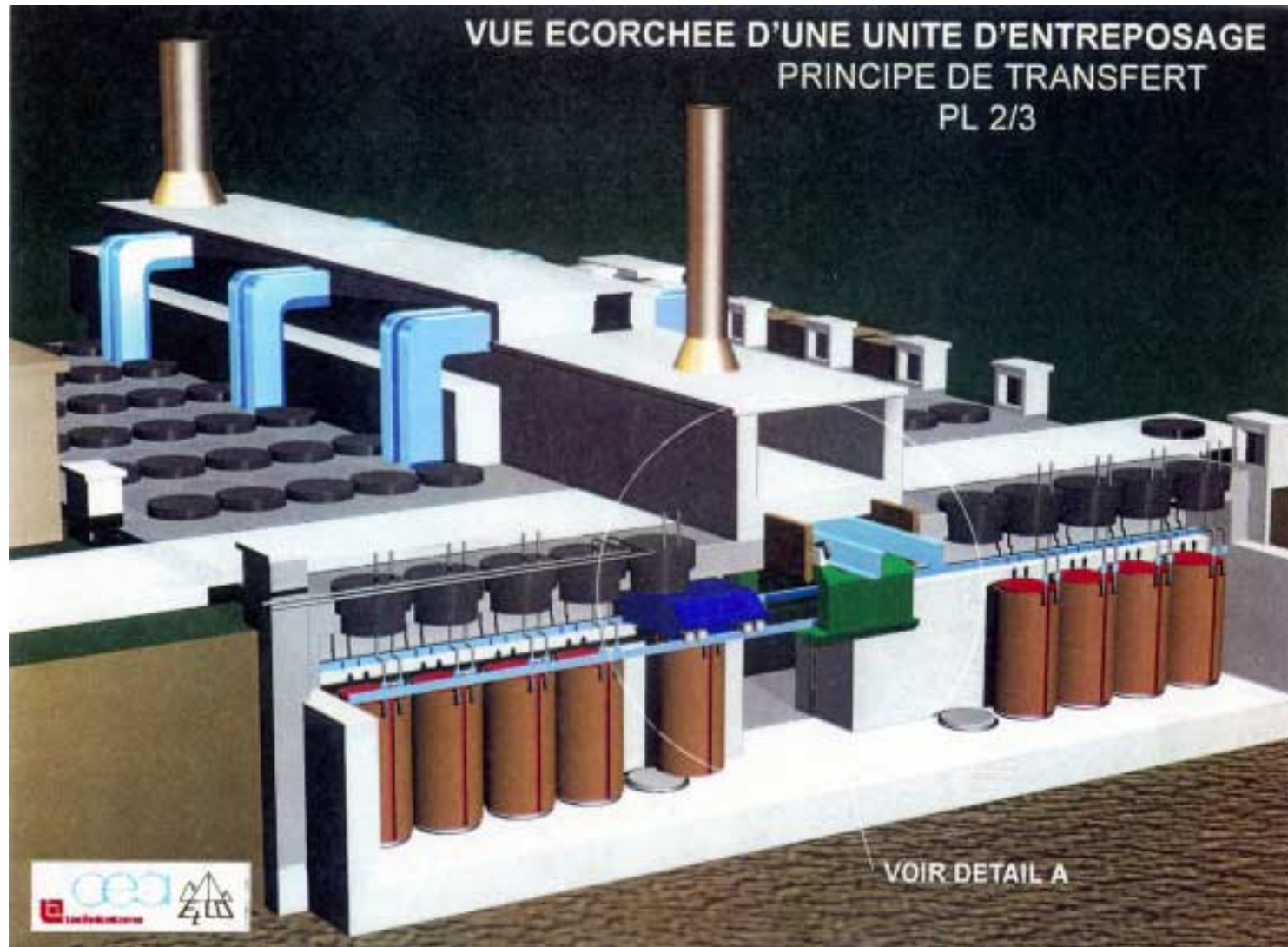
# Research Orientation – Long-term surface storage



# Storage Unit



# Research Orientation – Long-term surface storage



# **Research Separation by various chemical processes and transmutation**

- ▶ ***The reprocessing of spent fuel, the process retained by France, allows the various elements to be chemically separated.***
- ▶ ***It is thus possible to employ transmutation which allows long-lived radioactive waste to be transformed into short-lived radioactive waste or stable elements through nuclear reaction.***