Optimization of waste and materials disposition in France
Policy, strategies, and techniques

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IAEA-OECD/NEA –Studsvik
symposium April 6-10, 2014

Content

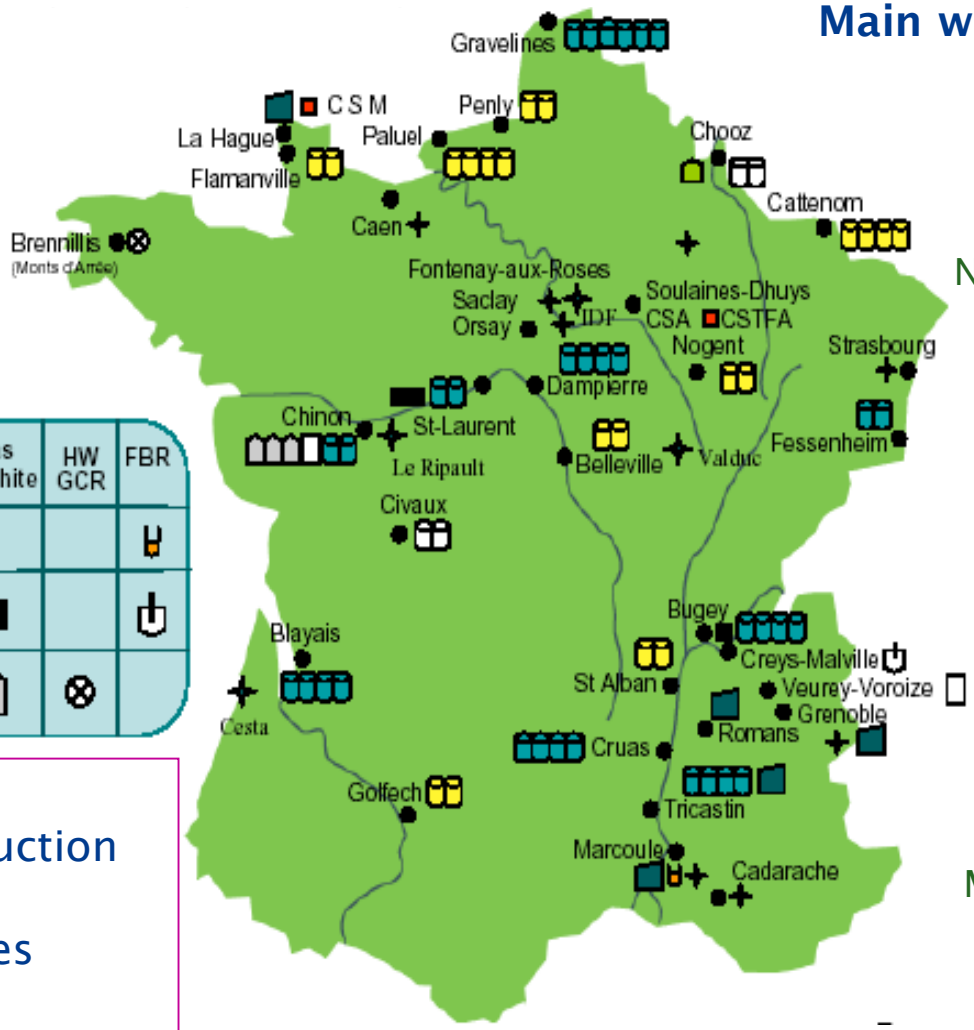
Recycling of metals arising from operation and decommissioning of nuclear facilities: the challenges in France

1. The landscape and involved actors in waste management in France
2. Present status of waste disposal in France: the issues
3. Policy, strategies: the national governance
   - The National radioactive wastes and materials management plan
4. Metals recycling
   - Present experiences in France
   - Very low level metallic waste recycling: some issues
5. Conclusion

The landscape and involved actors in waste management
A significant nuclear industry

Fuel Cycle Facilities
(enrichment, fabrication, reprocessing)
Waste Storages
Nuclear Research Centres
Laboratories

Reactors	PWR 300 MWe	PWR 900 MWe	PWR 1300 MWe	PWR 1450 MWe	Gas Graphite	HW GCR	FBR
In Operation (58)		■	■	■			■
Shutdown					■		■
Decommissioning in progress	■				■	■	



Main waste generators

EDF
Nuclear power plants

AREVA
Nuclear fuel cycle

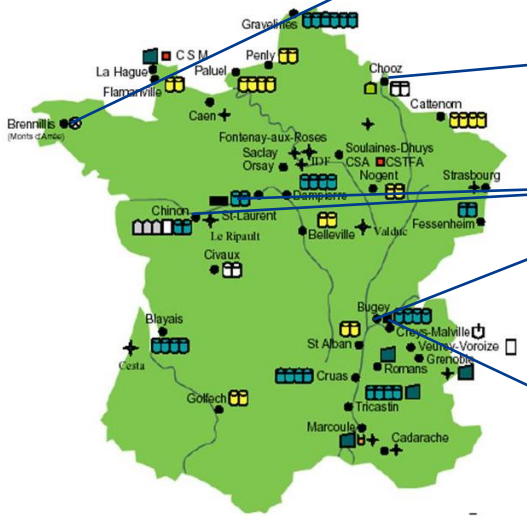
cea
Research
Military applications

58 PWR in operation
- 1 PWR under construction

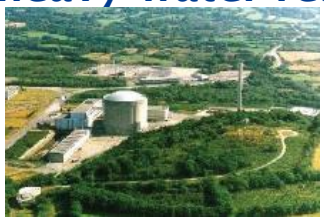
Fuel cycle facilities
Nuclear research centres
Military activities

Many different operating facilities, a significant decommissioning program,

The landscape and involved actors in waste management
EDF decommissioning programme

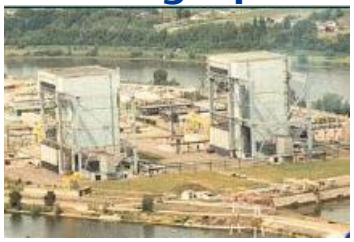


1 heavy water reactor



1 pressurized light water reactor

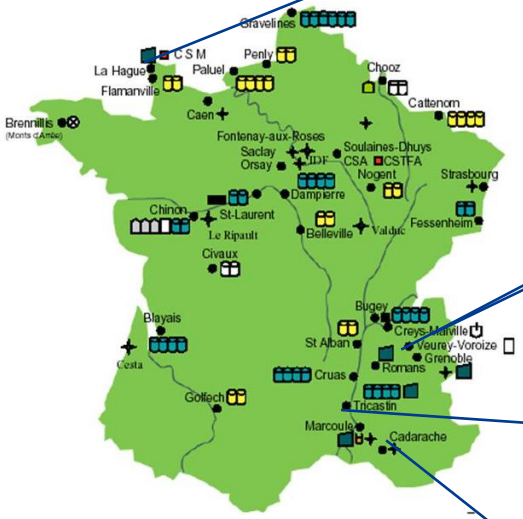
6 natural uranium graphite gaz cooled



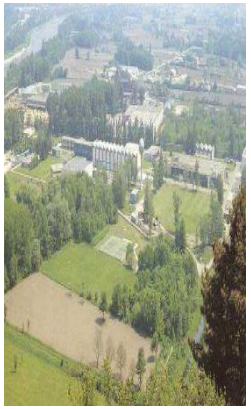
1 fast breeder reactor

The landscape and involved actors in waste management
AREVA decommissioning programme

Reprocessing plant



Fuel fabrication plants



Enrichment plant

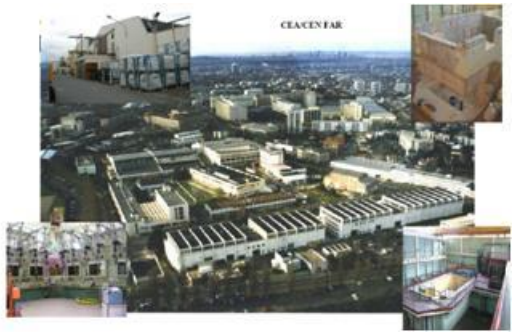
Some operations already completed

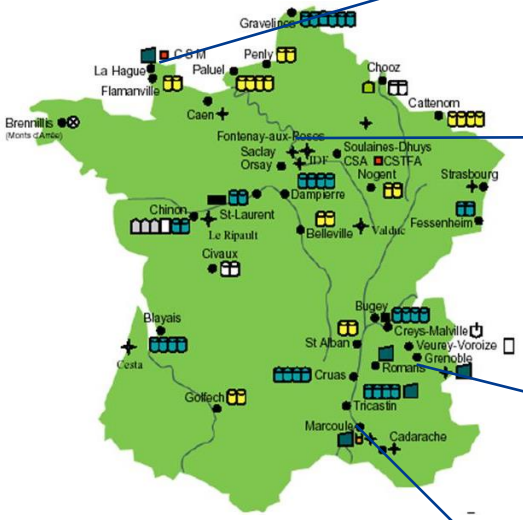
MOX Fuel fabrication plant

The landscape and involved actors in waste management
CEA decommissioning programme

Nuclear submarines

Fontenay aux Roses
Pilot facilities
for reprocessing



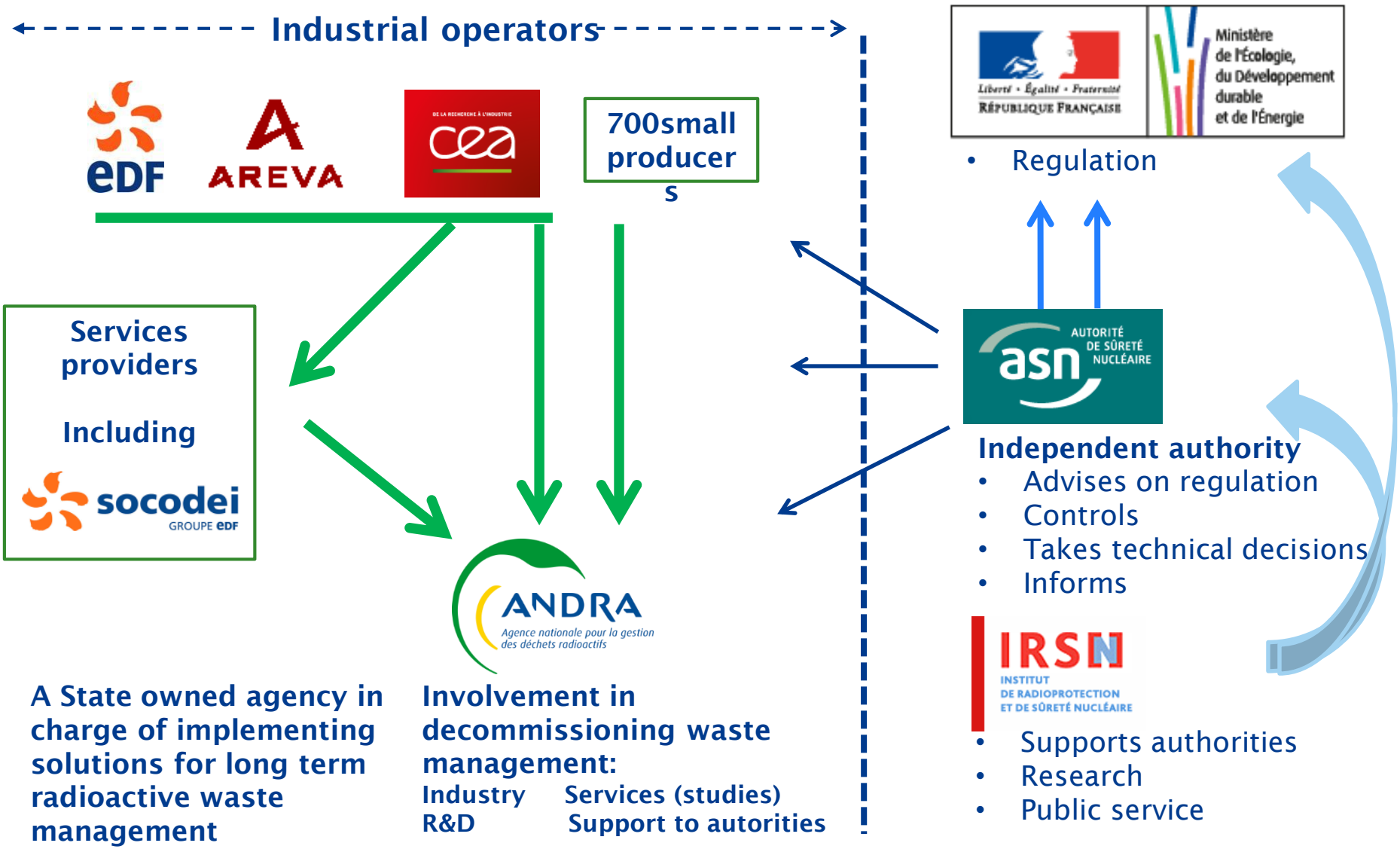


Some operations
already completed

Grenoble
Various facilities

Marcoule
Reprocessing
plant

The landscape and involved actors in waste management
The involved actors



A State owned agency in charge of implementing solutions for long term radioactive waste management

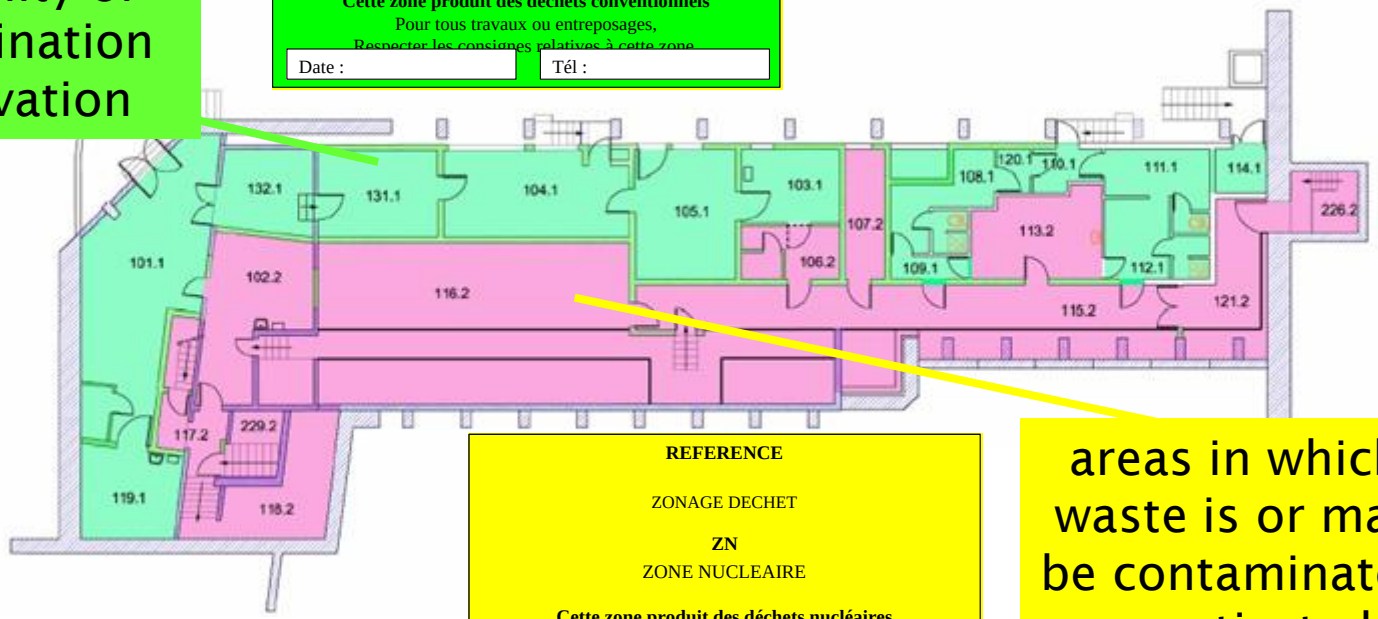
Involvement in decommissioning waste management:
Industry Services (studies)
R&D Support to autorities

The landscape and involved actors in waste management
A specific regulation for nuclear facilities

WASTE ZONING

areas where there is no possibility of contamination or activation

Conventional waste



areas in which waste is or may be contaminated or activated

Nuclear waste

No free release for nuclear wastes

Present status of waste disposal in France: the issues
Disposal operated and planned routes

More than 90% of the volume of waste have a disposal solution

RADIOACTIVE WASTE CLASSIFICATION

	Short lived waste (period of main nuclides < 30 years)	Long lived waste
Very low level	Operating Centre de Morvilliers	*Mining Residue*
Low level	Operating Centre de l'Aube	To be implemented Waste Act 28th June 2006 (graphite, radium **bearing**) Near surface
Intermediate level		
High level	Deep geological disposal (application planned in 2015, start up in 2025 – Waste Act 28th June 2006)	

First deliveries : October 2003

Centre de la Manche
Institutional control period since 2003

In operation since 1992

Bures URL

Storage for tritiated wastes

Present status of waste disposal in France: the issues
Situation of the operational routes

Centre de l'Aube

Operated since 1992

Licensed capacity : **1 000 000 m³**

Volume disposed of : **280 000 m³**
(end 2013)
(Centre de la Manche: 527,000 m³ disposed)

Present deliveries: **14 000 m³**

Initial design for operational waste (30 000 m³/year) . Initially forecast for 30 years of operation

VLLW disposal at CIRES (centre de Morvilliers)

Surface : **45 ha**

Licensed capacity : **650 000 m³**

Operated since 2003

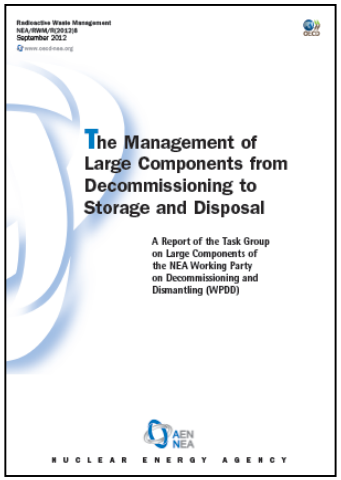
Volume disposed of (end 2013) : **252 000 m³**

Initial design for 30 years of operation

Present status of waste disposal in France: the issues
Disposal of large components

LL

Read this book !



Overall optimization

VLL

Present status of waste disposal in France: the issues
The issues for the operated disposal routes

Low level wastes

Waste generation forecast (2012)
1 200 000 m³ in 2030
(including 527,000 m³ at Centre de la Manche)

1 500 000 m³ after decommissioning of present or decided facilities

No volume problem to be anticipated

Very low level wastes

Waste generation forecast (2012)
1 300 000 m³ in 2030

2 000 000 m³ after decommissioning of present or decided facilities

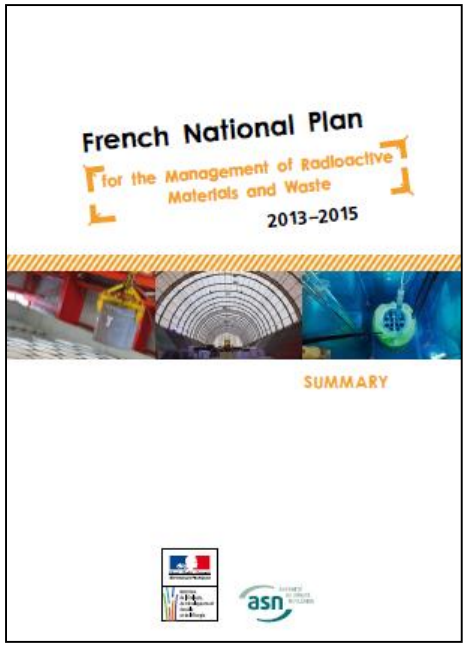
New disposal capacities needed

Legal framework: June 28th , 2006, waste act

Code of Environment: laws and regulation

Implementation of a National radioactive wastes and materials management plan (PNGMDR)

- Co-chaired by Ministry and ASN
- Involves
  - Ministries
  - ASN
  - IRSN
  - Operators
  - NGO
- Input : national inventory by Andra
- Develops the strategy for waste management
- Update every 3 years



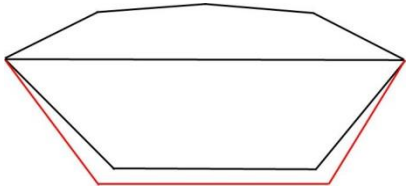
Policy, strategies: the National governance PNGMDR addresses metallic waste recycling

Disposal should be considered as a rare resource

- For VLL waste
  - Densification of waste
  - Densification of the disposal facility
  - Re-use of concrete scrap to backfill disposal cells
  - Recycling of metallic wastes

Program for 2010-2012:

- A shared study by the main French nuclear operators, AREVA, CEA and EDF, and Andra
- To assess the opportunity and economical/technical feasibility of the implementation of recycling routes.



In accordance with the French doctrine:

- recycling should be performed within the nuclear industry.
- Therefore stringent constraints on the traceability of materials.
- Potential constraints in the facilities that could process these materials
  - radiation protection
  - management of secondary wastes generated by the processes.

Metals recycling
Experiences in France: lead recycling

- Implementation by Areva in 2003 and operated by the CEA since 2005.
- Collection of lead inside Marcoule nuclear facilities,
- First melting inside Marcoule facility to make ingots (activity < 1 bq/g)
- Second melting in a conventional facility to manufacture shieldings,
- Recycling in nuclear facilities.
- 100 tons of lead per year currently recycled.
- However
  - a fourth of the capacity of the melting furnace
  - costly in comparison with a direct disposal in a VLL disposal facility.

- Therefore it is planned to stop this route.

Metals recycling
Experiences in France: melting facility of Socodei

- Electric induction furnace with a capacity of 4 tons
- Treatment of an average of nearly 1,700 t / year.
- waste outputs:
  - volume reduction : non-recyclable waste shipped as ingots to disposal facilities
    - LL ➔ VLL
  - Recycling: internal cylindrical shieldings for packages used for intermediate level waste (spent resins).
- Mean activity of metal that was process to make shielding: 6 Bq/g, with a maximum value of more than 160 bq/g.
- Between 1999 and 2011 21,700 tons processed
  - 600 tons recycled in shieldings.

LOW LEVEL RAD-WASTE VOLUME REDUCTION: THE CENTRACO FACILITY

socodei
GROUPE EDF

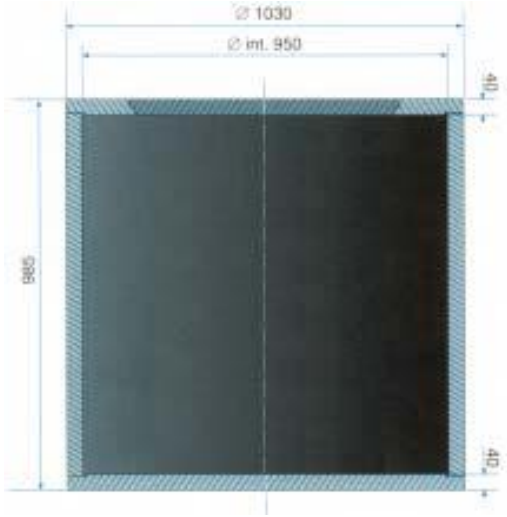
Waste acceptance criteria (melting)

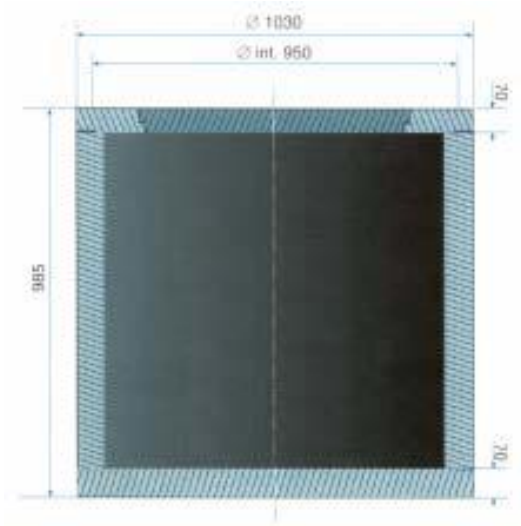
- Radiological criteria
  - *$\beta\gamma$-emitters: 20 000 Bq/g max + 20 000 Bq/g 3H*
  - *α-emitters: 370 Bq/g max*
- Physical and chemical criteria: limits on:
  - *Non ferrous*
- Conditioning accepted
  - *Melting: Reusable ISO CTRS & boxes, single use drums*

Tubular radiological shields (MERCURE ctrs) :

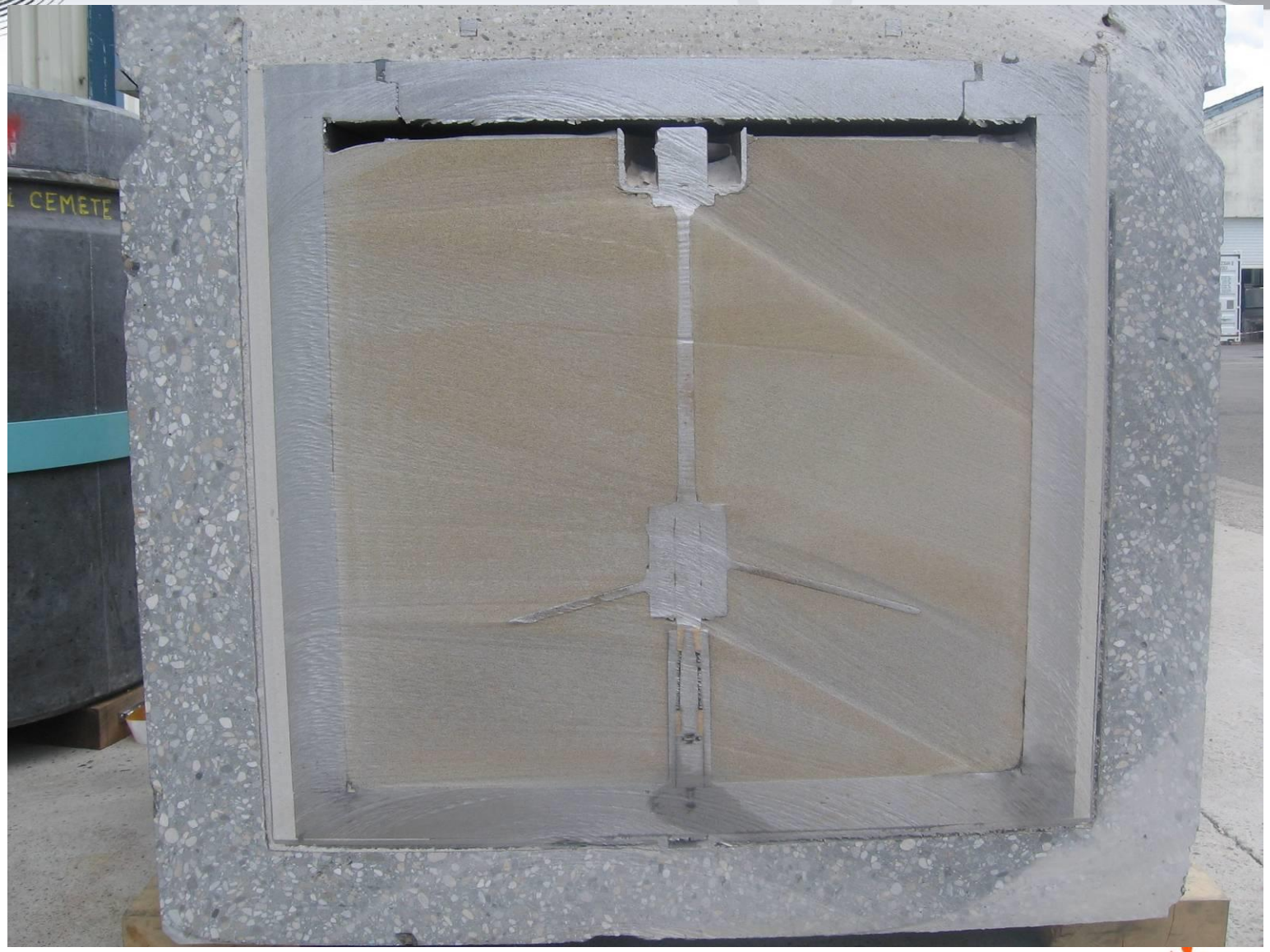
- Material: carbon steel
- Size : 100 x 100 cm ,
- thickness : 40 mm or 70 mm,
- Top, bottom & stirring bar : non radioactive carbon steel,

- These shields are incorporated in concrete shells to form shielded containers (300 years certification).
They are used for waste conditioning in the embedding processes.





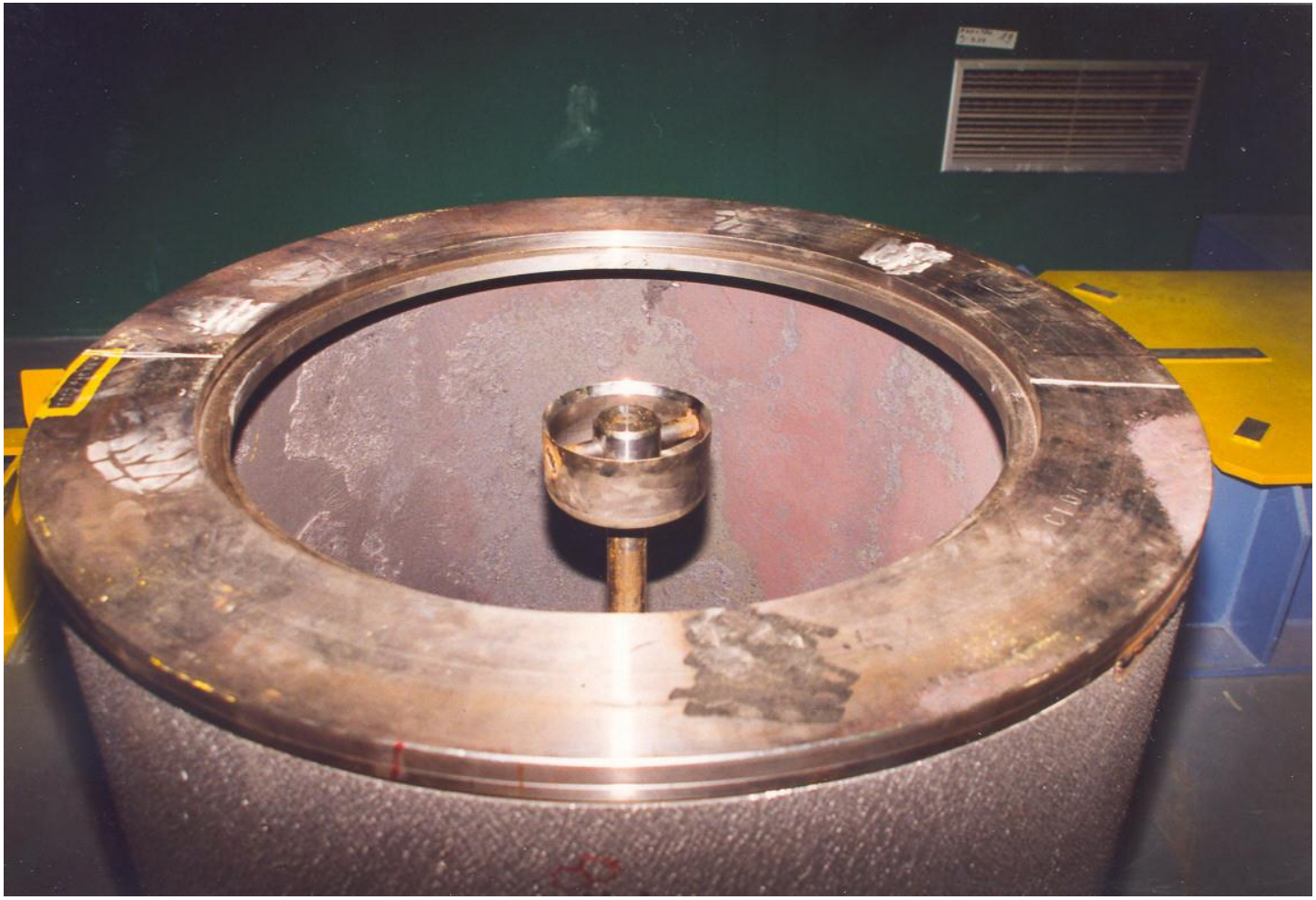
SEALED CONTAINER SECTION



Decontamination by melting

Centrifugation

Control of finished products



SPENT RESINS CONDITIONING

A review of the forecast inventory of metallic VLL waste to be generated

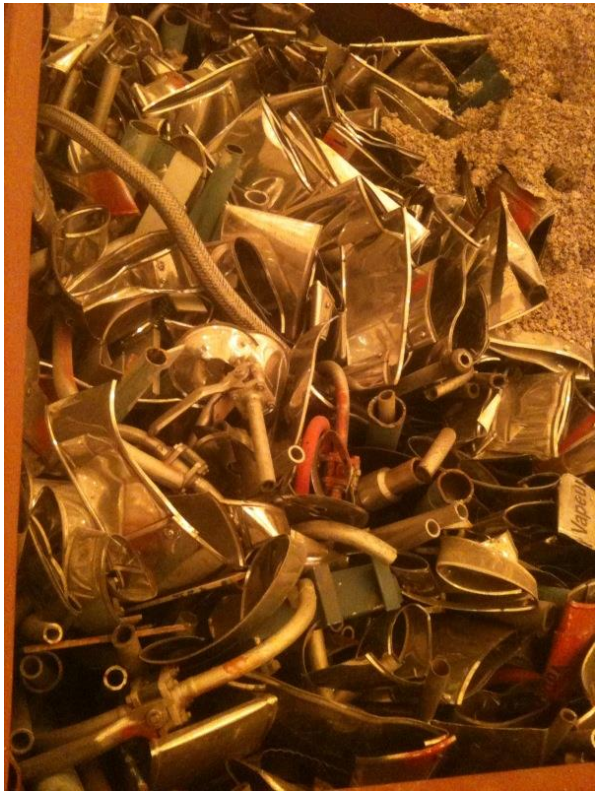
- 400,000 tons for the next 30 years
  - 250 to 375,000 tons with a very very low level activity
  - 90% of ferrous waste

5 to 10,000 tons easy to be recycled

- But 0.1% of conventional recycled steels in France

Homogeneous components: 140,000 tons from the dismantling of a gaseous diffusion enrichment plant

Other more heterogeneous



Metals recycling
Metals potential re-use

Recycling within the nuclear industry

Different types of products considered with a potential re-use of 300,000 tons for the next 30 years:

- Construction products in nuclear facilities with a focus on steel frames to reinforce concrete,

  But

  - Mainly steel materials
    - Not relevant to be processed in a dedicated steel facility (low quantities)
    - Generally manufactured prior use
    - Traceability constraints for re-use
      - *During implementation*
      - *When decommissioning the facilities (if planned)*

  ➔ Industrially and economically not relevant

- Packages to condition wastes with a focus on the replacement of LL concrete containers
  - Cast iron containers
    - Relevant with a dedicated cast iron facility (foundry)
    - Could enable volume reduction for LL and VLL waste packages
  - But
    - Re-assessment of disposal safety case needed
    - Modification of conditioning and handling tools in facilities where wastes are processed

  ➔ Significant industrial impact on operated facilities

  ➔ Significant costs forecast on waste conditioning facilities

Conclusion

No obvious short term outlet for VLL recycled metals in presently operated facilities

➔ Should rather be considered for new built facilities or opportunities

- New nuclear facilities
- New disposal facilities: components or packages
- …

Economical and industrial relevance as a major challenge

- Competition with direct VLL disposal route
- Sensitivity to constraints derived by the interpretation of the French regulation

New options to be explored and assessed

Still a sustainable development challenge !