FAST REACTOR TECHNICAL EXCHANGE MEETING

Status of Existing Fast Reactors in France

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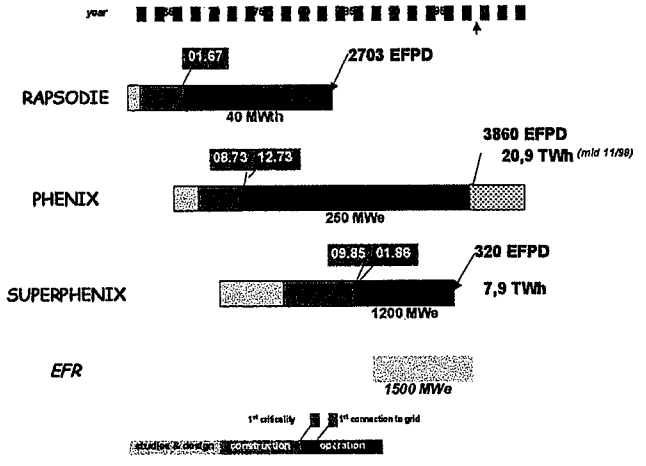
THE ATOM, FROM RESEARCH TO INDUSTRY

Fast Reactors in France : main data and milestones



1991 December 30th : French law on research for the management of radioactive wastes

Three research and development fields for 15 years, e.i. up to 2006

- Separation and transmutation on long-lived elements in radioactive wastes
- Possibilities of reversible or irreversible disposal into deep geological repositories through the building of underground studies laboratories
- Conditionning processes and long term surface storage processes of radioactive waste

Phénix and SuperPhénix : main dates

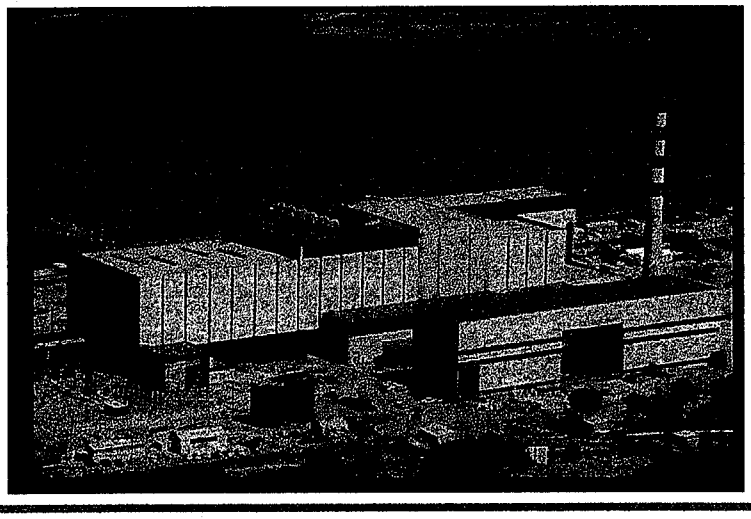
- In 1992, with regards to the incineration of long lived high level wastes, a report ordered by M. Curien (former Minister of Research and Space) notably concluded to the usefulness of experiments in Phénix and SuperPhénix
- In 1993 the Phénix Extension Life Project launched for refurbishing the plant ,
- In 1994 the KAP (Knowledge Acquision Programme) was implemented on SuperPhénix

These R&D actions were proposed, in coherence with the 91 law, in the framework of a global strategy including PWR's and FBR's to master irradiation product production and uranium consumption

Phénix and SuperPhénix : main dates

- **In June 1997, the announcement of the stopping of SuperPhénix was made, with important stipulation that safety was not at issue, final stop was decided February 1998**
- **in April 1998 9th , French Safety Autority gave the authorization to restart Phénix till 2004, with some restrictions:**
  - limited power 2/3 Pn
  - completion of renovation work in between run 50 and 51
- **the main objective of Phénix has been confirmed : to be an irradiation tool for transmutation experiments, partially including the programme foreseen in SuperPhénix**

Phénix general view



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Some data on Phénix operation (end of run 50)

	50th run	Since 1973
Equivalent full power days	77,3	3 860,5
Electricity production (GWh)	382,2	20 880,4
Connection to grid during (h)	3 019	99 811
Reactor critical during (h)	3 606	112 904

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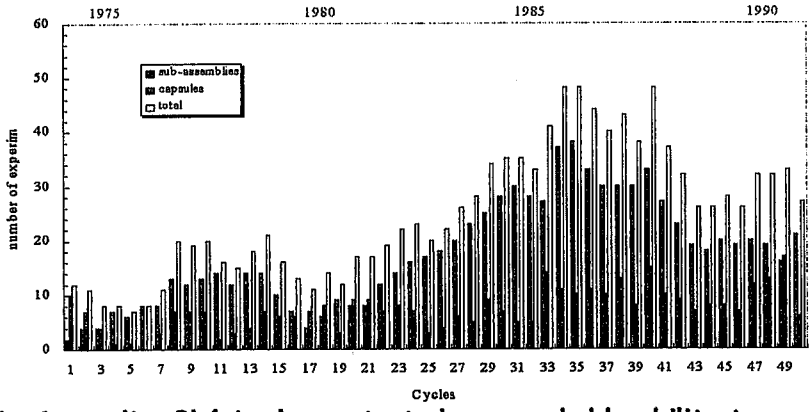
Phénix : an efficient irradiation tool



Like Rapsodie, Phénix demonstrated a remarkable ability to receive various and numerous experiments, thus enabling considerable progress in the knowledge of fuel behaviour.

Phénix, main dates

- **very good operation from 1973 to 1990**
- **Since 1990, a long period of works took place :** *to cope with the unexpected shutdowns of 1989 and 1990; to conduct repair works on the secondary circuit where cracking due to ageing phenomena appeared ; to refurbish the plant and answer safety requirements in view of extended operation.*
- **in April 1998 9th , French Safety Autority gave the authorization to restart Phénix till 2004**
- **the main objective of Phénix has been confirmed, to be an irradiation tool for transmutation tests, within the framework of the 91 law for:**
  - transmutation of MA and LLFP : SPIN programme
  - Improved Pu Consumption : CAPRA programme

Work on Phénix (1)

- **End of renovation work**
  - Reinforcement of buildings against earthquakes
    - reactor - 25% completed (as of September 99)
    - SGU - 80%
    - handling- 60 %
    - turbine buildings - 70%
  - Reinforcement of sodium fire protection inside SGU building (separation, ventilation, retention cans) 50%
  - Mitigation of the consequences of a steam pipes rupture
  - New ultimate cooling circuit (water/air, designed for seism) - 50%

Work on Phénix (2)

- **Inspection of primary circuit structures**
  - conical shell supporting the core
    - by US across 6 holes in the «double envelop» shell, made in July ; end expected in December
  - hanging structures of the vessel
    - by US in 3 zones inspected without problem
  - upper structures
    - by lowering the level of the sodium
    - observation of the ACS and S/A heads
    - position of S/A heads (to check that there is no significant modification of the core support structure)
- **Decennial maintenance works**

Works on Phénix IHX and SGU

- **3 new IHX were ordered**
  - defects detected on welds for two of them
  - repairing hinder the planning, at least 2 months
- **SGU : defects observed during inspection of a modulus**
  - origin demonstrated to be a non-evolutive fabrication defect, giving intergranular decohesion - 321SS delayed cracking excluded
  - inspection foreseen on 4 modulus from SGU 2
  - feasibility of ND inspection being studied

Expected operation of Phénix

- **Starting end of 2000**
- **taking into account the 2/3 Pn operation, a load factor of 70% and the interruns**

➡ **560 EFPD till end of 2004**

Experimental programme in Phénix

- **Comprehensive programme extending up to 2004**
  - mainly devoted to transmutation of radioactive wastes (MA & LLFP)
  - partially replacing the programme foreseen in SuperPhénix

➢ **Basic data**
  → 2 irradiations of samples of various isotopes
  → 1 experiment on moderator materials

➢ **Incineration of minor actinides**
  → homogeneous way : 3 experiments
  → heterogeneous way : 3 exp. on matrices
  4 on targets (+ 1 in HFR, 2 in BOR 60)

➢ **Destruction of long-lived fission products** - 2 exp.

➢ **Pu increased consumption** (CAPRA) 1 exp. (+ 1 in HFR, 1 in BOR 60)

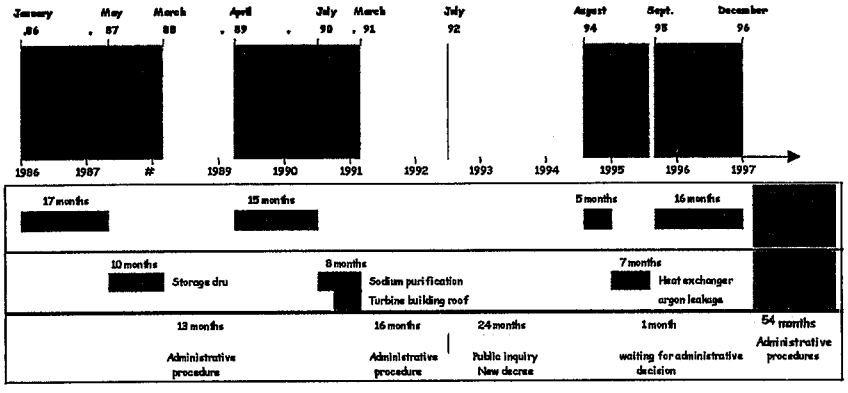
➢ **Structural materials** - 6 experiments

Super Phénix operation (1)

- Built and operated at Creys Malville by NERSA (F, I, D, Be, Ne) Super Phénix is a prototype of industrial size - 1200 Mwe -
- In 11 years, 4 serious incidents occurred ; none of them affected the safety of the plant ; a signifiant part of the interruption of production is due to administrative procedures.
- The operation in 1996 was quite remarkable and illustrated the potential of this type of reactor; the final shutdown prevented achieving a long-term demonstration.

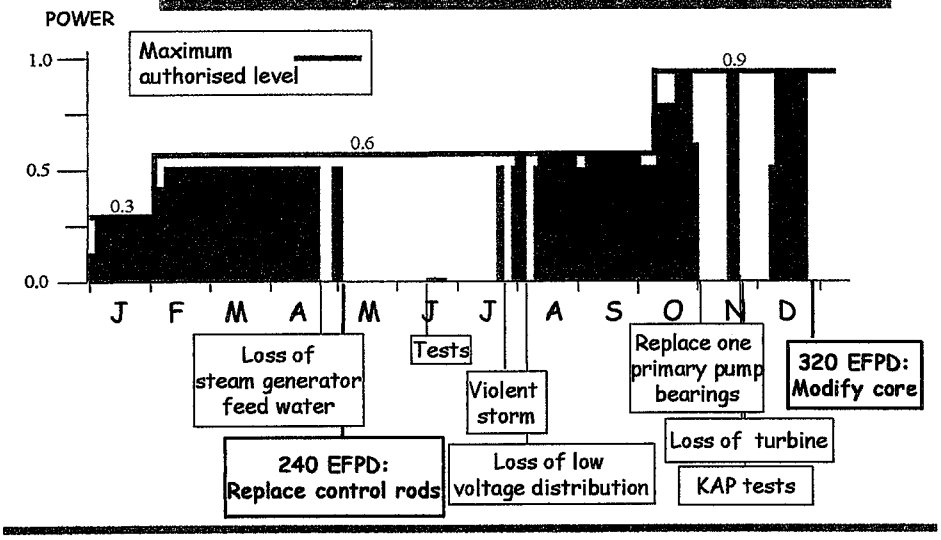
Super Phénix operation (2)

OPERATION BALANCE of CREYS-MALVILLE NPP



Output during operation period 7.9 TWh

Super Phénix 1996 operation



Super Phénix

- June 1997, decision of French government to abandon SuperPhénix, with important stipulation that safety was not at issue
- February 2nd 1998, the French government confirmed the stopping of SuperPhénix but, within the same declaration, underlined its support to reprocessing and recycling, and insisted that R&D must go on to keep the Fast Neutron Reactor option for the long term.
- December 1998, the decree authorizing the decommissioning was signed by the Prime Minister

Superphénix decommissioning (1)

- **Core unloading**
  - without dummy S/A
  - from periphery towards center
  - cooling : no need of pumps, provided the sodium is kept liquid ;
  - expected to start early 2000 for 18 months
- **Sodium heating**
  - possible by IHX and RUR, but not at the end of draining
  - installation of an electrical heating system completed at the end of August 99
    - heating wires and heat insulator on the outside of safety vessel ~ 600 Kw

Superphénix decommissioning (2)

- **Sodium draining**
  - storage in existing tanks
  - problem of retentions
    - in the diagrid ≈ 12 m^3
    - in the catcher trays ≈ 11.5 m^3
    - in the bottom of the vessel ≈ 8.5 m^3
    - will be eliminated by drilling
- **High pressure water/steam circuits being put out of service**
  - water admission pipes and steam outlet pipes were cut

Superphénix decommissioning (3)

- **Dismantling of small components and secondary circuits being studied**
  - carbonatation to deal with sodium
- **Waste treatment**
  - sodium : NOAH process, then neutralisation of soda in Na_2SO_4
  - primary and secondary cold traps ; discussion to use the ATENA facility
  - specific facility considered for metallic wastes of secondary circuit

Superphénix till 2005

- **Status expected in 2005**
  - core unloaded
  - primary and secondary sodium removed
  - main sodium retentions eliminated
  - remaining sodium
    - film 3 tons
    - puddle 3 tons
  - secondary circuits carbonated and dismantled

Main lessons from Phénix and Superphénix

- Industrial validation of the parameters, including large size, of sodium cooled fast reactor .
- The main design options - fuel, circuits .... - are validated, as the design codes and criteria, the feed back from experience is important.
- The operation and the incidents provided precious information on important issues such as : metallurgy, sodium chemistry, instrumentation, in-service inspection, behaviour of components, prevention of risk associated to sodium.
- The safety level is comparable to that of a PWR.

Conclusions

- According to the 91 French law on the management of radioactive wastes, R&D on the feasibility of transmuting long-lived actinides and fission products is carried out.
- A large programme is underway on Phénix, till 2004 for transmutation of Minor Actinides and Long Lived Fission Products and Pu increased consumption tests
- Till 2005, the first phase of SuperPhénix decommissioning will be done to reach IAEA level 1.
- In 1998, a governmental statement underlined support to reprocessing and recycling, and insisted that R&D must go on to keep the Fast Neutron Reactor option for the long term.