2 Construction Review

Abstract

Superphenix reactor construction has been achieved within approximately seven years from March 1977 up to the beginning of the filling-in with sodium in August 1984. *D0* being the beginning of the construction site (March 3, 1977), the reactor sodium infilling was completed at *D0* + 89 months instead of *D*0 + 55.5 months, i.e. a 33.5 month slippage. The overnight construction cost was approximately 7.7 billions € 2012. The delay taken during construction has two main causes:

- The novelty and the specificity of fabrications. In particular, many manufacturers have had to create workshops and train their personnel for this prototype construction.
- A European organization, which was making the governance cumbersome, which was enforcing some task distributions among the countries and which was making more complex the works follow-up and the general quality assurance.

However, this construction site has been a technological feat, with the development of techniques specific to the sodium-cooled fast reactor type, in particular, with on-site fabrication and transportation of very large diameter parts, an integrated fast reactor feature.

A European Reactor

General Organization

The owner for Superphenix reactor construction will be NERSA Company, a public limited company under French law, established on July 8, 1974. Its capital is initially distributed as follows: 51 % EDF, 33 % ENEL and 16 % SBK (SBK is a company under German law grouping RWE, Electrabel, Dutch SEP and British Nuclear Electric).

J. Guidez and G. Prêle, *Superphenix*, DOI 10.2991/978-94-6239-246-5_2

For this purpose, a law had been enacted on December 23, 1972, authorizing the creation of organisations applying in France European interest activities in terms of energy. This law was followed by a decree signed by the Prime Minister on May 13, 1974 authorizing the creation of NERSA.

Following the recommendations of the Peon Commission, Chirac government authorizes NERSA to pass order in April 1976. On May 2, 1977, Barre government signs a decree of declaration of public utility of Creys-Malville power plant and, on May 12, 1977, an authorization decree of a 1200 MW_e fast neutron nuclear plant creation on Creys-Malville site.

Construction Site Beginning Date

The land had been purchased in 1973 and preliminary earthworks carried out from 1974 to 1976.

On January 1, 1977, the civil engineering contract will be signed and on March 26, 1977, the reactor block ordered to the Novatome/Nira consortium. In January 1977 will begin the first works of the base mat (see Fig. 2.2).

Excluding these preliminary operations, works officially began on March 3, 1977, date that will be chosen as *D0* in the initial schedule and in all the subsequent manufacturing schedules (Figs. 2.1, 2.2 and 2.3).

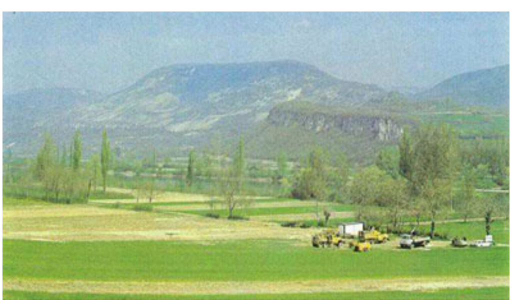

Fig. 2.1 Site initial photo in 1974

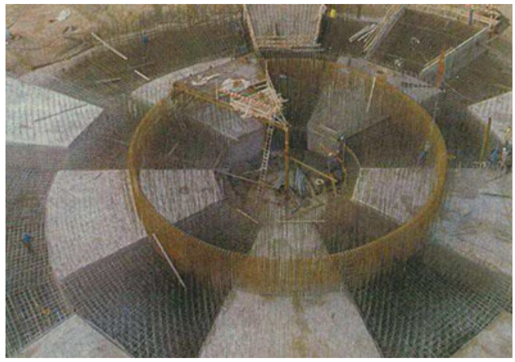

Fig. 2.2 View of the base-mat reinforcement steel in progress on January 20, 1977

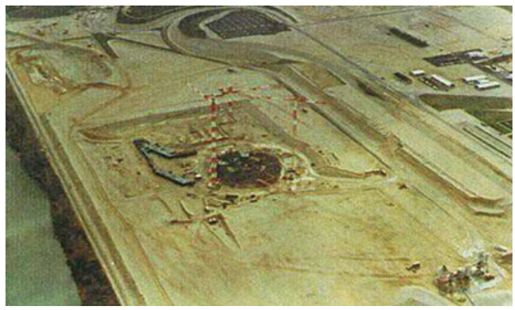

Fig. 2.3 View of the site in March 1977 and of the preliminary works situation

Industrial Organization

Superphenix is therefore a European reactor where several foreign companies do bring their capitals so as to know this promising technology, but desiring make their domestic industry work in proportion of their participation.

This will therefore have major consequences in the distribution of industrial tasks. Table 2.1 shows clearly Italian and German supplier involvements. Seventy main contracts will be signed with thirty-five European companies. This will be a factor making more complex with extra costs the construction site general organization.

It will also lead to imposed technical choices. For example, the turbine had been entrusted to ANSALDO. This company having no turbine with 1240 MW_e capacity, the reactor will ultimately be fitted with two 620 MW_e turbines, and thus with two complete turbine hall equipment

Table 2.1 Italian and German supplier involvements

	France	Italy	Germany, BENELUX
Civil engineering	Fougerolle	Condotte d'acqua	Philip Holtzman
Reactor block			
Dome		NIRA, BELLELI	
Main and internal vessels		NIRA, BREDA, ATM CIMI	
Dummy diagrid—diagrid	NEYRPIC	NIRA, BREDA	
Core cover plug		NIRA, BREDA	
Rotating plugs	NEYRPIC	NIRA, BREDA	INTERATOM
Rod mechanisms	NEYRPIC		
	NOVATOME/NEYRPIC	NIRA, ATB, FOCHI,	
Safety vessel	(NOVATOME)	NIRA, TERMOSUD,	
Emergency system (RUS circuits)		DALMINE	
Neutron shielding	SICN		
Core	COGEMA CEA	AGIP NUCLEAIRE	
RUR			Royal Schelde
Circuits			
IHX	STEIN Industrie	NIRA, BREDA, TOSI	
Pumps	Jeumont SCHNEIDER	NIRA FIAT	
SG	NOVATOME		
Valves and taps	BOUVIER	NIRA	
Sodium/air heat exchangers	DUCROUX NEYRPIC	NUOVO PIGNONE	
Circuits (excluding components)	STEIN Industrie		
	ACB		
	DELATTRE LEVIVIER		
Integrated purification	NOVATOME		
Argon purification	STEIN Industrie		
	Air Liquide		
Protection against fires	DELATTRE LEVIVIER		
	NEU		
Handling			
S/A internal handling	NOVATOME	NIRA CMI	INTERATOM
S/A evacuation	NEYRPIC	NIRA FOCHI	NOELL/STEINMULLER
Fresh S/A reception	NOVATOME		
Handling casks	ACB		INTERATOM
Washing decontamination			

(continued)

Table 2.1 (continued)

	France	Italy	Germany, BENELUX
Electricity supplies–instrumentation and control			
Safety systems	CGEE ALSTHOM		
Pump drive motors	MERLIN GERIN		
Automatisms	CGEE ALSTHOM	NIRA ANSALDO	
Regulation	SODETEG		SIEMENS
Power systems	NEYRTEC	ELSEL	
Information treatment	NOVATOME	NIRA CMI	SIEMENS
DRG LRG (clad failure detection/location)	THOMPSON CST		SIEMENS
Special measurements	SEIV		HARTMANN/BRAUN
	MERLIN GERIN		BBC
Turbo-generator sets		ANSALDO	

(water stations, steam piping, condensers, water treatment, etc.). This was not going in the direction of optimizing costs or optimizing subsequent operating conditions.

This will also be the source of some technical Issues, due to follow-up difficulties at less known providers, non-usual and with different languages.

This organization is one of the identified causes of the construction site extra deadlines and extra costs.

Nevertheless, it may be noted that Superphenix benefited from the skills acquired by some companies: NOVATOME, ex GAAA, STEIN-INDUSTRIE, NEYRPIC and JEUMONT in the continuity of Phenix realization.

The Overall Progress of the Reactor Block Construction Site

The Fabrications in On-site Workshop for Large Diameter Structures

What characterizes integrated-type sodium-cooled fast reactors is the need for large fabricated and all-welded structures with thin thicknesses and large diameters, in particular, at the primary circuit; for example the main vessel is 21 m in diameter, 25–60 mm thick.

Handling such parts is awkward and their transportation by rail or road impossible.

Their manufacturing is then carried out in four phases.

- Maximum factory prefabrication (for example, by starting from rolling strips provided by the steelmaker) so as to obtain transportable elements, for instance, for the slab, six central elements and six peripheral ones.
- Assembly of these elements in a fabrication workshop built for that purpose on the site so as to obtain a number of packages.
- Implementation of each package in the reactor building through a temporary breach (36 × 28 m) located 37 m above the ground. The breach in the containment wall will be closed after having introduced the last package.
- The package final mountings are then carried out there, as well as all introductions and end-of-mounting works.

Other Manufacturing and Exceptional Transports

The basic rule is to manufacture in factory all that can be, the limitation being sizes and weight.

Fig. 2.4 On site arrival of a steam generator

Fig. 2.5 The diagrid (8.9 m in diameter) passing through a village

This is how the diagrid will be manufactured in Italy and the rotating plugs will be manufactured by Neyrpic at Grenoble (in two pieces for the large rotating plug).

The large rotating plug two pieces will be assembled on site, in the workshop, and the small rotating plug will be mounted in the large one. Rotation tests will be conducted before placing them into the reactor.

The large components: pumps, intermediate heat exchangers, steam generators were manufactured in factory and transported onto the site, as well as all other various equipment (rod mechanisms, rotating transfer lock, cold traps, etc.) and secondary circuit different parts.

Fig. 2.6 Plant construction conditions in August 1978

This will lead to exceptional transports for conveyance to the workshop before assembly and installation.

The Civil Engineering

Reactor Block

As soon as the base mate was completed, the civil engineering works for the reactor block construction do start and are about to continue in

Fig. 2.7 Reactor pit and storage drum pit construction

Fig. 2.8 The reactor block construction continues with the transfer gantries

parallel with the workshop ones, so as to receive the packages that will be manufactured in it (Figs. 2.7 and 2.8).

On-site Workshop

This workshop should take into account:

- The volume of packages to be assembled: the most cumbersome package was the safety vessel (22.5 m in diameter and 15.9 m high).
- Their weight: the heaviest package was the slab: 850 tonnes before concreting.
- Their height: the highest package was the primary pump.
- The maximum number of packages to simultaneously realize (Fig. 2.9).

A metal shed, 114 m long, 60 m wide, supporting travelling cranes with 25-m hook clearance, was selected. It has two 21.24-m spans, with 4 mounting areas. One area includes 7-m deep pit, intended for the pump final assembly. Each span is serviced by travelling cranes (two 80-tonne cranes that can be coupled to the north and two 35-tonne ones to the south).

This workshop is connected by rail to the reactor building, enabling the package transportation to the containment foot where they were taken over by two gantries each with 426-tonne capacity, and 31.3-m span, enabling the introduction of these packages through a breach in the reactor building.

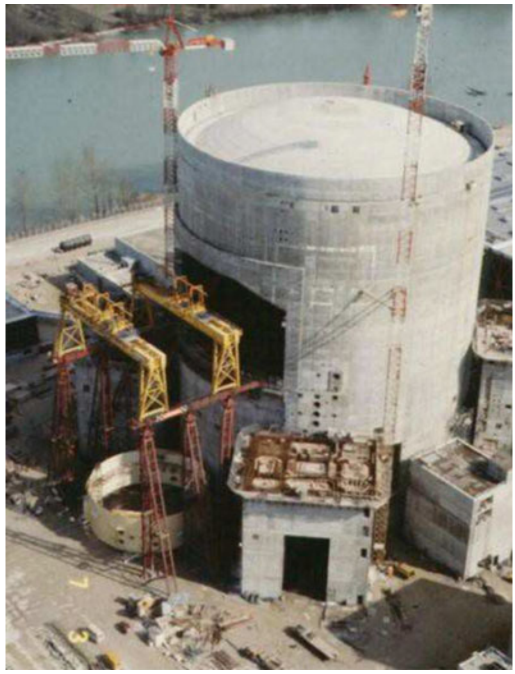

Fig. 2.9 The reactor block and its gantry are ready to receive the packages manufactured in the workshop

The Manufacturing in the On-site Workshop

The Notion of Package

The package is a set mounted in the on-site workshop, which will be transferred in one piece into the reactor building for final connection onto the adjacent components.

The constitution of a package enables, in better working conditions, to very far push forward the reactor pre-assembly and to work in parallel by increasing the number of workstations. This also enables to continue in parallel the in-reactor civil engineering works as well as the preliminary assemblies.

The major packages constituted from 1978 to 1980 were:

Fig. 2.10 View of the workshop built simultaneously and already in operation

Fig. 2.12 Fabrication in simultaneous activities of several packages in the on-site workshop

- The safety vessel (22.5 m in diameter, 15.9 m high, weighing 260 tonnes).
- The reactor main vessel fitted with the core catcher, the B1 baffle and the core support plate (21 m in diameter, 15.6 m high excluding its upper part beforehand connected to the slab (called "on hold piece"), weighing about 700 tonnes).
- All internals: conical and toroidal inner vessel sections, baffles, pump skirts and heat exchanger chimneys (package 20.4 m in diameter, 10.6 m high, weighing approximately 600 tonnes).
- The diagrid (8.9 m in diameter, 1.2 m high, weighing 120 tonnes).
- The slab (25.7 m in diameter, 2.7 m high, weighing 850 tonnes).
- The two rotating plugs (12.4 m in diameter, 5.47 m high, 850 tonnes).
- The dome (400 tonnes).

The storage drum retention vessel, the storage drum main vessel and the sodium storage tanks will also be manufactured in the on-site workshop.

Manufacturing and Storage Methods

The base elements are made in factory, where 1.8-m long steel strips are cold-formed, prepared (edge machining) and welded so as to form a transportable set.

In the on-site workshop, the main operations will be these structure pre-assembly and then welding, which can be either in stainless steel

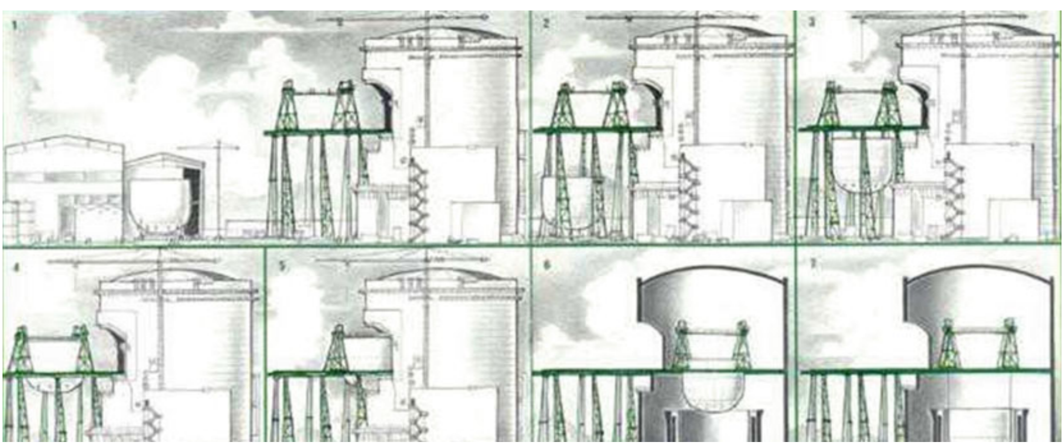

Fig. 2.11 Package handling and setting up in the reactor block diagram

Fig. 2.13 In-workshop manufacturing of the main vessel, of the B1 baffle and, at the back, of inner vessel structures

(vessels, etc.) or in low alloy carbon ferritic steel (slab, storage drum, etc.). The welding quantity to achieve was very significant: e.g. 800 m welds for the only main vessel. All welds were performed manually.

Welding quality goes through:

- the preparation of the joint form (geometry, clearance, …);
- the control between each welding runs (usually by dye penetrant testing);
- a 100 % radiographic control at the end of operation.

The main challenges were as follows:

- Taking into account size, weight, distortion and support issues.
- Respect of desired final tolerances, essential for some functional imperatives but also for the final assembly in the reactor block.
- Very good knowledge of welding shrinkage issues, necessary for different types of materials, of thicknesses and geometry.
- Taking into account cracking and residual stress risks, all the more that the stress relief post-welding heat treatments are not possible for these large parts.
- Cleanliness and protection, as manufactured areas do lose their accessibility, there must be protections (vinyl, etc.) so as to ensure the final cleanliness.
- Support and transport. The packages have the size of a 4–5-storey building. Their support and their transportation mode must prevent excessive stresses and distortions.

The Package Transfer and Assembly in the Reactor Block

The transfer is achieved in two phases:

- Transport on dollys in the on-site workshop and outside, up to the dual gantry crane grip.
- Lifting up, translation and putting down using the dual gantry crane. Two gantry cranes, 426 tonnes each, are coupled covering on one side the reactor building outside and on the other side the inside, moving through a 36 × 28-m breach in the containment, 37 m above the ground.

Transfers began when the two pits, reactor block and storage drum, had been completed and equipped with their cooling circuits (water circuits for the reactor pit, and by an air ventilation for the storage drum pit).

First Package: The Safety Vessel (260 t)

This package was the most voluminous one. The safety vessel will be put on pads fitted with cylinders (Fig. 2.14).

Second Package: The Main Vessel + The Core Catcher + The B1 Baffle (700 t)

This package will be put down into the safety vessel via chocks (Figs. 2.15, 2.16 and 2.17).

Fig. 2.14 Arrival of the first package (safety vessel) in the reactor block

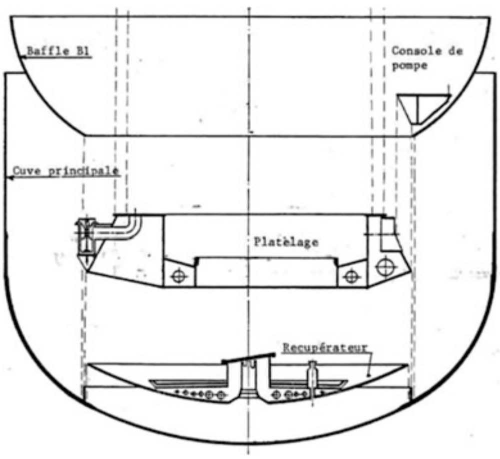

Fig. 2.15 The second package layout

Third Package: Conical and Toroidal Inner Vessels + Baffles + Chimneys + Pump Skirts (560 t)

See Figs. 2.18, 2.19 and 2.20.

Fourth Package: The Reactor Slab

This was the heaviest package with the rotating plug one (850 tonnes with the handling equipment). This slab will be subsequently filled-in

Fig. 2.16 Introduction of the main vessel into the safety vessel. The chocks between the two vessels are visible

Fig. 2.17 View of the second package on its chocks in the safety vessel

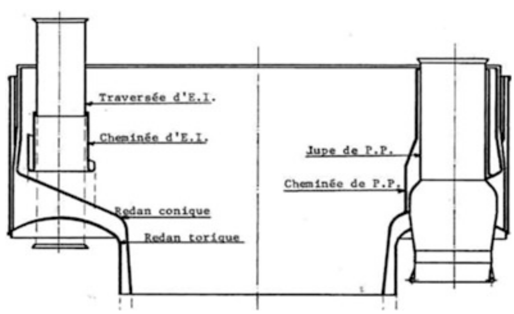

Fig. 2.18 Third package block diagram

with concrete on the spot (biological protection concrete).

Fig. 2.19 The third package getting out from the workshop, on rails

Fig. 2.20 Introduction of the third package into the main vessel

Main Vessel/Slab Welding

Cylinders do raise both packages 1 + 2, which enables to present the top of the main vessel in front of the "on hold piece" embedded in the slab, for the connecting weld. It should be noted that the vessel is in austenitic steel and the slab in ferritic steel. The heterogeneous welding was carried out in the on-site workshop on this "on hold piece", which makes the in-reactor welding homogeneous and easier (Figs. 2.21 and 2.22).

Welding Safety Vessel/Slab

After having removed the chocks between the two vessels, the safety vessel can be brought up

Fig. 2.21 Arrival of the reactor slab

Fig. 2.22 View of the slab being laid down

so as to be welded to the slab “on hold piece”. Then cylinders and supports are removed

All welding operations inside the vessel (inner vessel/core support plate, B1 baffle, etc.) were carried out in parallel.

Setting-up the Dead Body

An anti-convection device is called “dead body”, it is set at the bottom of the reactor hot pool. It restricts hot sodium circulation in this area, so as to reduce the thermal gradient on the conical inner vessel (Fig. 2.23).

Setting-up the Dome Cylindrical Body

See Fig. 2.24.

Setting-up the Diagrid

The diagrid manufactured in factory will be located at the bottom, on the core support plate (Fig. 2.25).

Setting-up the Rotating Plugs

Assembled and tested in the workshop, this is also the heaviest package (850 t).

After the rotating plugs were set up, the core cover plug was installed.

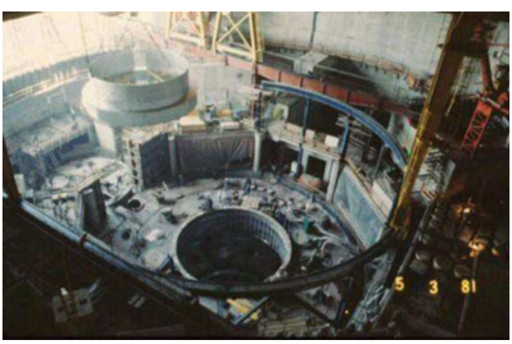

Fig. 2.23 Arrival of the dead body

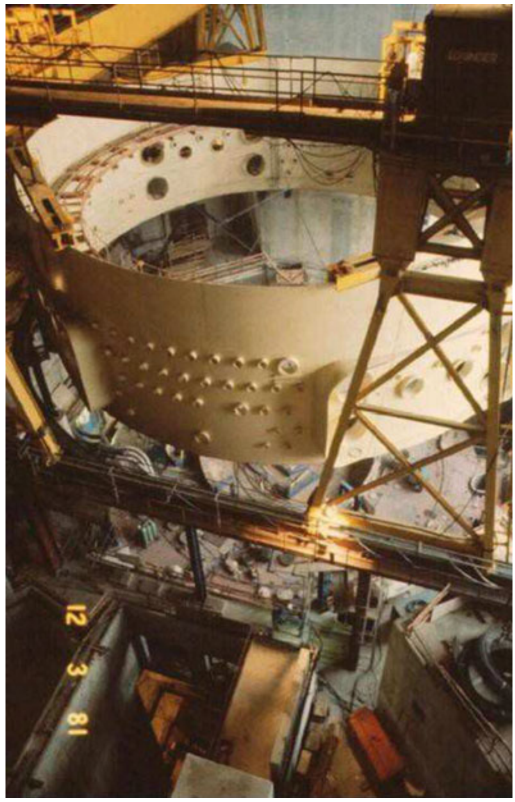

Fig. 2.24 Setting-up the dome cylindrical body

Setting-up the Dome (400 t)

The dome is introduced and stored in an area outside the pit, which enables to continue the introductions at the pit (in particular of large components), while starting the works to close the containment breach.

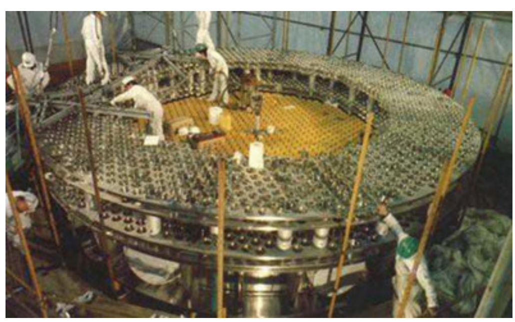

Fig. 2.25 view of the diagrid being prepared

Fig. 2.26 Lifting the two rotating plugs

Fig. 2.27 Dome arrival

Then works do continue with the assembly of the pump/diagrid links, the core cover plug, primary pump, intermediate heat exchanger setting-ups, etc. (Fig. 2.27).

Figure 2.29 summarizes, in its outlines, the order of all these operations.

Setting-up the Storage Drum

In the meanwhile, in 1980, the storage drum and its retention vessel were handled and set-up in their vessel pit.

Fig. 2.28 Assembling the pump/diagrid link

Works Finalization

After the large components had been introduced, works will continue with the cable fitting, instrumentation, etc. more conventional operations.

A dummy core will also be loaded so as to prepare filling-in with sodium and the trials (see Chap. 3 "Start-up Trials").

Works in the Plant "Conventional" Part

Of course, the plant construction is not limited to the reactor block and to the handling facilities: these positions are the specific ones for fast reactors. The other sodium positions, such as the secondary circuits or the sodium discharge/storage circuits, are achieved on the basis of elements manufactured in factory and did not pose any particular problem.

As to conventional parts: auxiliary buildings, turbine hall, command and control electrical equipment building, pumping station, various auxiliaries, etc., their realization did take place without any particular specificity. It will simply be noted that, in the absence of 1240 MWe turbine availability, ANSALDO installed two 620 MWe turbines (Figs. 2.32 and 2.33).

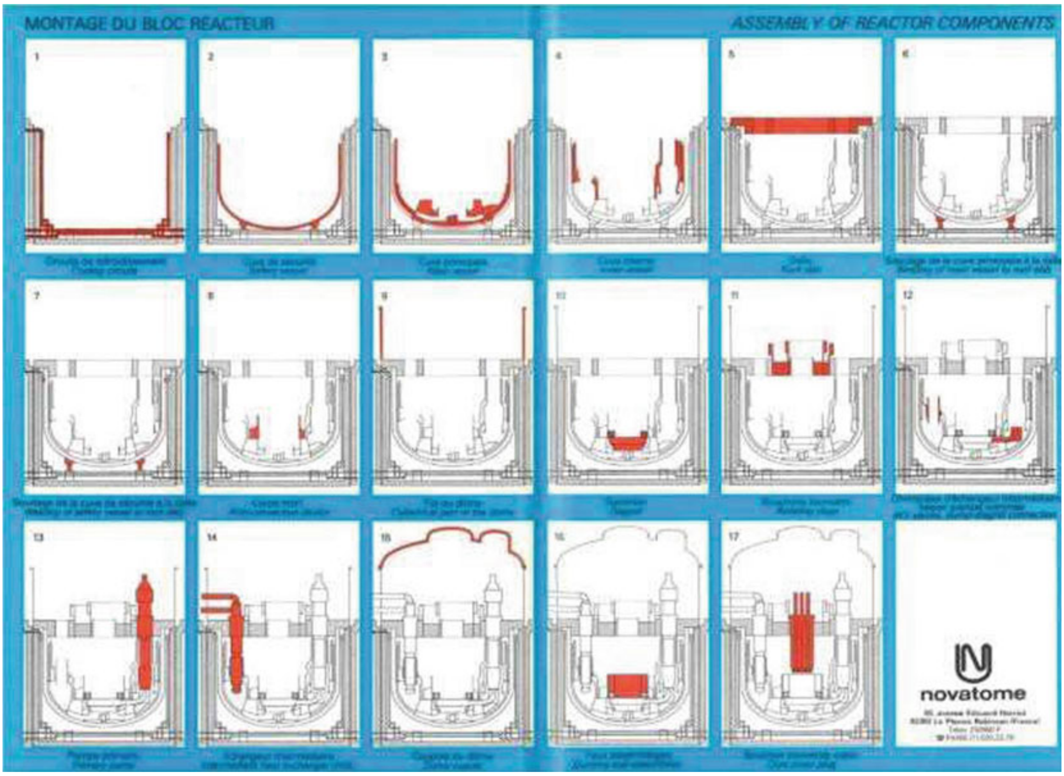

Fig. 2.29 Reactor block assembly time diagram

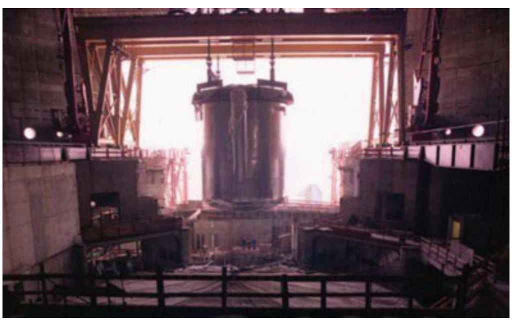

Fig. 2.30 The storage drum arrival upright its pit

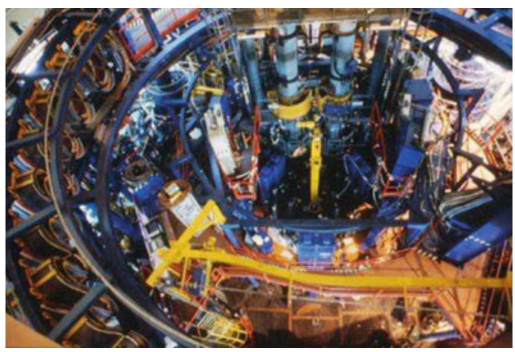

Fig. 2.31 View of the space above slab at the end of works

The Schedule

The original schedule so as to reach the rated power was *D0* + 70 months. The retained D0 was held on March 3, 1977, due to notified anticipations on the final contract signature.

The final schedule will be 112 months, so there was 42-month slippage.

The schedule presented in Fig. 2.34 summarizes the main actions during the construction period that would have lasted just over seven years, from March 1977 to August 1984.

Fig. 2.32 Assembling the last high-pressure stage of one of the two turbines

Fig. 2.33 View of one of the two turbine halls in 1984

From 1984, this is the period when the reactor is filled-in with sodium and then the trials are carried out and the reactor is got critical, before the rated power is reached (see Chap. 3 "Start-up Trials"). This rated power will therefore be reached a little less than ten years after the first concrete pouring.

The fabrication was completed at *D0* + 81 months instead of 50, i.e. 31-month delay.

Among the causes of this delay, it has to be noted the reactor building polar crane failure in October 1980, during its under-load test, which will result to repair in situ and to switch handling to other less appropriate lifting equipment.

The storage drum filling-in with sodium is completed at *D0* + 87 months (instead of 49), and then the secondary circuits at *D0* + 87 months (instead of 53) and the primary one at *D0* + 89 months (instead of 55.5).

As a conclusion, at the sodium infilling, the final delay was 33.5 months.

Then, in particular because of final cable fitting issues for instrumentation and control, of component testing delays and of difficulties on the turbines, the delay will rise to 37.5 months for the criticality (101 for 63.5), 39 months for the connection to the grid (105 for 66) and 42 months to reach the rated power.

One of the reasons for this delay, besides to the already mentioned international coordination issues, was the prototype aspect for the entire involved manufacturers who often have had to create the workshops, the corresponding machines and train their personnel. This prototype aspect could also be found on the site where were fabricated and transported the greatest nuclear components ever manufactured for a reactor (Figs. 2.34 and 2.35).

The Costs

The Construction Costs

The 2012 report of the Court of Auditors [1] on nuclear costs presents a chapter on Superphenix, where the total cost is given at 12 billion euros 2010, i.e. about 12.5 billion euros 2012, over the period 1974–1997. This cost comprises the construction amounts, the total cost attributable to the plant, including operating costs.[1] This global value obviously does not enable to come back to the construction cost.

However and to allow for comparisons, all values that will be given later on costs are updated in euros 2012. This update was performed using a specific formula based on various indices: TP01, ICHTTS and AICC,[2] which

[1]The report of the Court of Auditors states that this figure does not include any costs for dismantling.

[2]This is the formula P = P0 (1/3 AICC + 1/3 TP01 + 1/3 ICHTTS), which prevents:– The underestimate led by a simple use of the consumer-price INSEE index.– The overestimate related to sharp indicators for raw materials

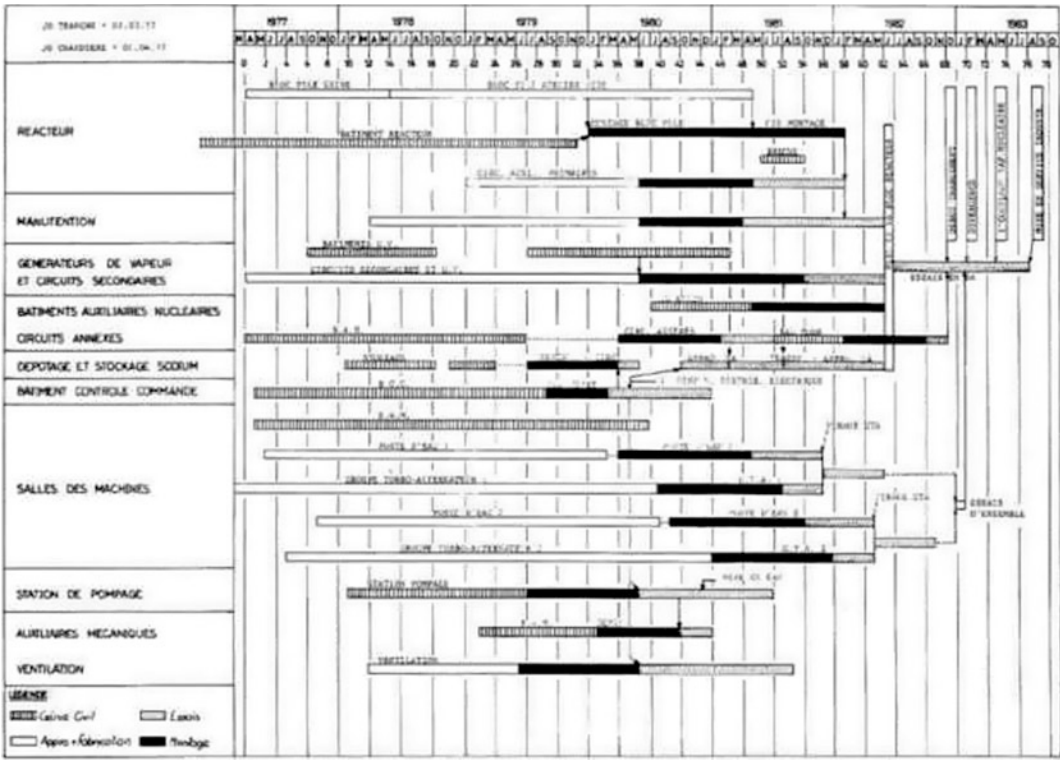

Fig. 2.34 Construction schedule

CONSTRUCTION	* Début des opérations de génie civil	Janvier	77	
	* Atelier site terminé	Mars	78	
	* Introduction du 1er colis dans le bâtiment réacteur	Mai	80	MISE EN SERVICE
	* Début livraison sodium	Mai	81	
	* Introduction du dernier colis dans le BR	Octobre	81	
	* Fin des montages circuits	Mi	83	
	* Remplissage sodium du circuit primaire	Août	84	
	* Divergence	Septembre	85	
	* 1er couplage réseau	Janvier	86	
	* Puissance nominale	Décembre	86	
		10 ans		

Fig. 2.35 Simplified operation schedule

enables to take into account the increase in nuclear unit construction costs.

A 1998 Parliamentary Inquiry Commission report on Superphenix is produced [3]. In this report, it is written that Superphenix construction cost is 28 billion nominal Francs, interest and fuel costs included, i.e. approximately 10.5 billion euros 2012. This figure is also cited in Ref. [4] and in NERSA or EDF internal documents. It should be noted that this is a very comprehensive construction cost. Not only it incorporates the interests and the cost of two cores, the latter being of 2 billion nominal Francs, but also the costs of pre-operating and rental of plutonium. If are only considered the single cost of bills paid to suppliers for the construction (APEC included), with construction engineering costs and pre-operating expenses, it leads to an "overnight"[3] cost of 17.7 billion nominal Francs, i.e. 7.7 billion euros 2012.

(Footnote 2 continued)
(copper, rolled steels) that are volatile indices giving too much weight to market effects, which are dependent on supply and demand.

[3]The construction period generates costs (interest paid during this period) that reach a significant amount of the total cost. The overnight cost is the one without these interests, so it is the building cost that should have been paid if the plant had been built "in one night" (hence the term overnight).

Batch/Set/Subset	SPX quote
Infrastructures/ Buildings	2.8%
Civil engineering	11.1%
Reactor	26.3%
Secondary loops + SG	8.9%
Primary auxiliaries and handling	13.3%
APEC	7%
Turbine hall	16.4%
Electrical / control systems (I&C)	6%
Electricity others	3.2%
Ventilations	0.7%
Handling miscellaneous	1%
Electricity generating station auxiliaries	2.3%
Instrumentation and control excluding nuclear island	1%

Fig. 2.36 Distribution of construction cost by set

It should however be noted the sensitivity of this value in the retained update formula. The direct use of the national INSEE index (for consumer prices), although it is less suitable for nuclear unit construction costs, would lead to a lower value of about 5.7 billion euros 2012, for this overnight cost.

The construction cost breakdown, including the APEC facility, is presented in Fig 2.36.

Although this section is devoted to the construction, for information, it can also be provided other cost elements (extracted from [4]): operating costs were approximately 1 billion nominal Francs per year. It is clear that the sale of the electricity produced, with a reasonable load factor, would have covered these costs.

Benchmarking with Water Reactors

The high investment costs will lead to an estimate of a 2.3 factor on the cost per kWh between Superphenix and a PWR, with 1982 economic conditions [3].

This extra cost is essentially related to two factors.

The first is intrinsic to this type of reactors, for example the existence of secondary loops. Then the different position weight and cost comparisons show extra costs, in particular for fuel handling and the reactor block equipment. This analysis was performed for the following projects, SPX2 and EFR, where a number of provisions helped to save about 45 % on the weight of the necessary equipment: shortened secondary circuit, single inner vessel, handling, etc. (see Chap. 25 “Superphenix Children”). The need, for each sodium circuit, to have at least two auxiliary circuits (cover gas, filling-in/purification) also contributed to the cost higher than for an equivalent-sized PWR plant.

The second is related to the prototype aspect and to the implementation of necessary industrial processes and skills. For example, for sodium pumps, Jeumont Schneider have had to create the white workshop required for these pump construction, to develop the processes and computer codes, to recruit and train staff, etc. CREUSOT-LOIRE/NOVATOME encountered the same problem on steam generators, where it had been necessary to develop specific machines for their manufacturing, or for Italian companies having to manufacture of a nine-metre in diameter diagrid, etc. All this led to extremely substantial extra costs in regards to “in series” production likewise, at the time, for the PWR type of reactors.

The Other Construction Sites

As a reminder, the site will experience three other major construction sites excluding the initial project, and apart from small worksites usual to a plant (offices, halls, etc.).

In 1984, with the construction of the irradiated sub-assembly warehouse (APEC)

Fig. 2.37 APEC construction site state in March 1985

Fig. 2.38 Construction of the reactor block/APEC corridor in March 1985

This construction was decided in 1982, following the unknowns about the creation of a specific fuel reprocessing plant. This facility enables the in-water storage of several spent cores with the corresponding transfer chain. Its construction will run from 1984 to 1989. The APEC provides the storage for approximately 1400 sub-assemblies in a water pool and a hall for storing about 300 more sub-assemblies (Figs. 2.37 and 2.38).

In 1988, with the replacement of the storage drum by the in-gas fuel transfer station (PTC)

This construction will be completed in two years from 1990 to 1991 (see Chap. 22 "The Handling").

In 1992, with a worksite for modifications so as to improve the sodium fires prevention and control

This worksite will last for approximately two years, from 1992 to 1994 (see Chap. 14 "Sodium Leaks and Fires").

Conclusion and Recommendations

- The manufacturing in an on-site workshop of the reactor large thin parts was a first in the world for these sizes and a recognized technical success. The general methodology with manufacturing in an on-site workshop the large parts was fully validated.
- The development of automated welding methods for this type of materials would be a notable improvement factor.
- The seven-year construction duration, as stated by the concerned manufacturers, and based on that time regulatory constraints, could have been reduced below the five-year line in a repeated and therefore more industrial scheme.
- Despite the European prototype aspect, extremely penalizing in terms of cost and schedule, the final result, with seven-year construction for 7.7 billion euros 2012 is, retrospectively, a very honourable performance.

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http://www.springer.com/978-94-6239-245-8

Superphenix
Technical and Scientific Achievements
Guidez, J.; Prêle, G.
2017, XL, 342 p. 342 illus., 283 illus. in color.,
Hardcover
ISBN: 978-94-6239-245-8
A product of Atlantis Press