1 OF 1

FOR OFFICIAL USE ONLY

JPRS L/8426

27 April 1979

WEST

EUROPE

# FRANCE: NUCLEAR, MISSILE, AND SPACE DEVELOPMENTS
FOUO No. 459

U. S. JOINT PUBLICATIONS RESEARCH SERVICE

FOR OFFICIAL USE ONLY

NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

JPRS L/8426

27 April 1979

# FRANCE: NUCLEAR, MISSILE, AND SPACE DEVELOPMENTS

FOUO No. 459

CONTENTS PAGE

NATION'S ELECTRONUCLEAR PROGRAM'S PROGRESS DETAILED

French Electronuclear Program

Paris REVUE GENERALE NUCLEAIRE in French Dec 78 pp 450-475

/Text/ The French electronuclear program which began in three phases -- 1970, 1974, and 1976 -- succeeding the "graphite-gas generation," is proceeding in conditions that on the whole appear to be satisfactory. Of course, there have been some delays in the start of service of the first power plants ordered, but it seems that such delays should gradually be recovered during the next few years. This becomes apparent in the articles that we are publishing here today. The first two deal with the 900 MW level of the PWR /Pressurized Water Reactor/ process. Special attention is paid to Fessenheim, the first power plant of this type to start operating in France. The current status of the 1,300 MW PWR program is described in the third article, and the last part of our report discusses the development of Super-Phenix, the large 1,200 MW breeder plant now being built at Creys-Malville.

Status PWR Construction Program

Paris REVUE GENERALE NUCLEAIRE in French Dec 78 pp 451-459

/Article by Eloi Chardonnet, head of the 900 MW level in EDF's Equipment Division/

/Text/ The author gives the essential features of the 900 MW level. He then discusses the current status of all the segments of this level, going into the issues of procedures, studies, civil engineering, construction of equipment in factories, assembly, tests, and the start of service.

Before presenting the current status in the various aspects of construction of the 30 units or "segments" which make up this level, we should briefly review the essential features characteristic of this level and the doctrine underlying all the activities involved in it.

Within EDF /French Electric Power Company/, the policy of developing levels of segments generating electric power preceded the present development of the nuclear program. But the importance of this program, begun in 1970, then greatly accelerated in 1974, and the scale of the problems entailed in studies and in industrial planning led EDF to make maximum use of this policy in all the areas involved: standardization of segments, grouping contracts for specific equipment and awarding all the work to the same builder, adaptation of the distribution of work to this situation, etc. The advantages of this standardization, the problems it caused, the methods and resources used were discussed by Mr Brignon in an article which appeared in REVUE GENERALE NUCLEAIRE, issue no 6 of 1977, to which the reader may be interested in referring. Some additional information on the definition of the 900 MW level, on its development program, and on the distribution of jobs within EDF's Equipment Division are given hereafter.

Definition of the 900 MW Level

This level includes 30 units assembled two by two in 15 pairs or segments, forming four successive series:

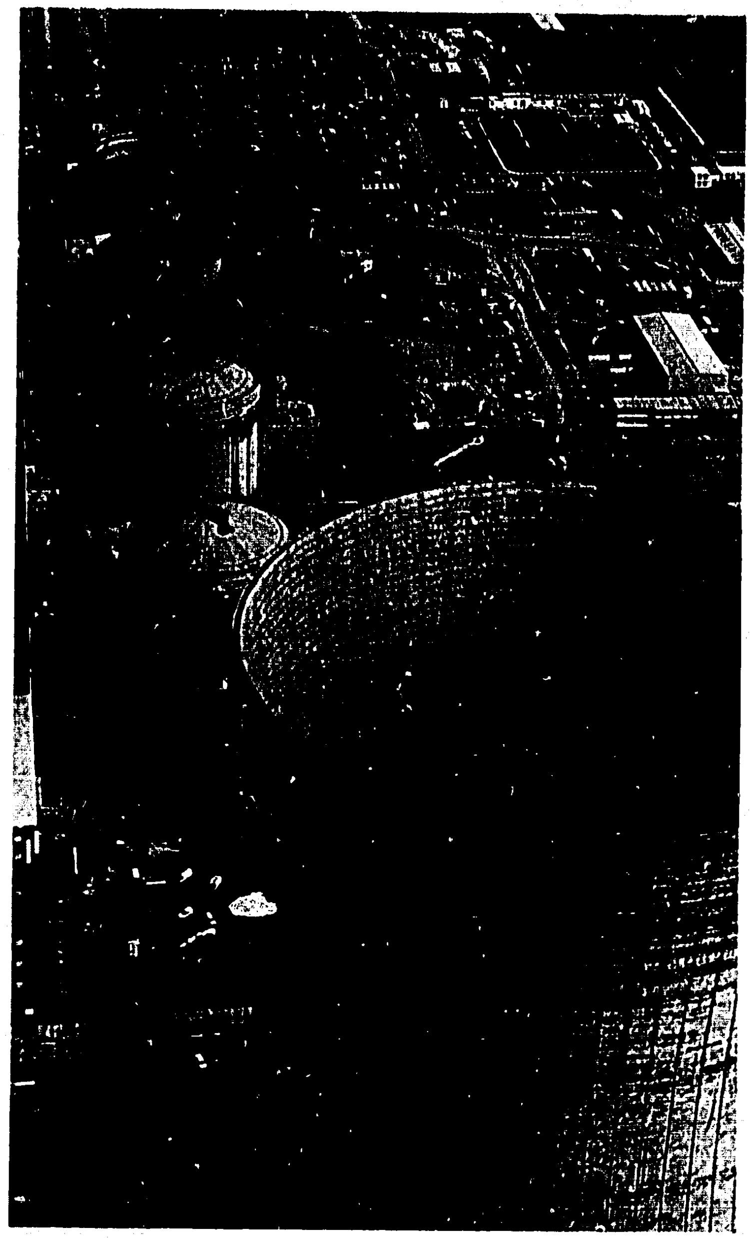
1. Fessenheim 1-2 (two segments)

2. Bugey 2-3 and 4-5 (four segments)

3. CP 1 type: Tricastin 1-2 and 3-4, Gravelines 1-2 and 3-4, Dampierre 1-2 and 3-4, Blayais 1-2 and 3-4 (16 segments)

4. CP 2 type: Saint Laurent 1-2, Chinon 1-2, Cruas 1-2 and 3-4 (eight segments).

Each pair of segments includes a standard part covering the essentials of construction; this is identical for all the pairs of the same series (with the exception of a few adaptations to meet local conditions). The actual parts specific to each pair concern essentially some of the annex buildings and in part the cooling circuits, whose plans are obviously closely linked to the site conditions.



Dampierre-en-Burly (May 1978).

The plans for the Bugey segments are not much different from the plans for the Fessenheim segments, from which the Bugey plans are very directly derived. The experience acquired in the study and construction of these first two power plants was put to use in the definition of the CP 1 plans, which do conserve the major lines of the architecture of the earlier Fessenheim and Bugey power plants, with machine rooms placed tangentially in relation to the cylindrical reactor building. For the CP 2 type, the nuclear block part is an identical reproduction of the preceding ones, but the overall layout of the construction was changed, giving a radial arrangement to the machine room, which led to a complete individualization of this part of the facility for each segment.

Of the 30 segments, 16 are cooled with open circuits: Fessenheim 1-2 on the Rhine, Bugey 2-3, Tricastin 1-2 and 3-4 on the Rhone, Gravelines 1-2 and 3-4 on the North Sea, Blayais 1-2 and 3-4 on the Gironde river.

The remaining 14 are cooled with closed circuits using cooling towers: Bugey 4-5 on the Rhone, Dampierre 1-2 and 3-4, Saint Laurent 1-2, Chinon 1-2 on the Loire, and Cruas 1-2 and 3-4 on the Rhone.

The Chinon and Cruas power plants each deserve mention of a special feature: cooling with induced draft at Chinon, where powerful blowers (8 MW in all) take the place of a natural draft; and a special foundation on neoprene studs for Cruas. This made it possible to avoid special reinforcement of the structures to adapt construction to local seismic conditions.

Development Program

Fessenheim 1-2: begun in 1970, segments connected to the network in 1977.

Bugey 2-3 and 4-5: begun in 1971, segments 2-3 connected in 1978. Connections of 4-5 scheduled in 1979.

CP 1 type: first segment begun in 1974. Connections scheduled in 1979 (for the first segment of Tricastin, Gravelines, and Dampierre), 1980, 1981, and 1982 (the last two Blayais segments).

CP 2 type: first segment begun in early 1976. Connections scheduled in 1980 (first segment of Saint Laurent), 1981, 1982, 1983, and 1984 (the last two segments of Cruas).

Table I presents in detail the connection target dates now scheduled. All the planning for the various jobs is based on these dates. The delay in the nuclear program which has actually occurred or which is made official in the target date is shown in this table, which for each segment shows the slippages observed or expected. It is believed that these slippages can gradually be reduced from nearly 2 years for the first segments to zero for the last ones. The last segments obviously benefit from the research and development done throughout the entire program.

| Tranches | Objectifs initiaux couplage | Objectifs couplages au 15/11/1978 | Glissements |
|---|---|---|---|
| Fessenheim 1 | 06/75 | Réalisé 6/4/77 | 22 mois |
| Fessenheim 2 | 04/76 | Réalisé 7/10/70 | 18 mois |
| Bugey 2 | 08/76 | Réalisé 10/5/78 | 21 mois |
| Bugey 3 | 06/77 | Réalisé 21/9/78 | 15 mois |
| Bugey 4 | 03/78 | 03/79 | 12 mois |
| Bugey 5 | 08/78 | 07/79 | 11 mois |
| Tricastin 1 | 10/78 | 08/79 | 10 mois |
| Gravelines 1 | 12/78 | 07/79 | 7 mois |
| Dampierre 1 | 03/79 | 11/79 | 8 mois |
| Tricastin 2 | 05/79 | 12/79 | 7 mois |
| Gravelines 2 | 07/79 | 01/80 | 6 mois |
| Dampierre 2 | 10/79 | 05/80 | 7 mois |
| Triscastin 3 | 12/79 | 07/80 | 7 mois |
| Gravelines 3 | 02/80 | 08/80 | 6 mois |
| St-Laurent B1 | 09/80 | 10/80 | 1 mois |
| Tricastin 4 | 06/80 | 11/80 | 5 mois |
| Dampierre 3 | 04/80 | 01/81 | 9 mois |
| Blayais 1 | 10/80 | 03/81 | 5 mois |
| Gravelines 4 | 11/80 | 04/81 | 3 mois |
| St-Laurent B2 | 03/81 | 04/81 | 1 mois |
| Dampierre 4 | 01/81 | 06/81 | 5 mois |
| Blayais 2 | 06/81 | 09/81 | 3 mois |
| Chinon B1 | 10/81 | 10/81 | 0 mois |
| Chinon B2 | 03/82 | 03/82 | 0 mois |
| Blayais 3 | 05/82 | 05/82 | 0 mois |
| Blayais 4 | 11/82 | 11/82 | 0 mois |
| Cruas 1 | 03/83 | 03/83 | 0 mois |
| Cruas 2 | 08/83 | 08/83 | 0 mois |
| Cruas 3 | 02/84 | 02/84 | 0 mois |
| Cruas 4 | 08/84 | 08/84 | 0 mois |

Table I: General Construction Program for the 900 MWe PWR Segments.

Key:

1. Segments
2. Initial target dates for connection
3. Target dates for connection as of 15 Nov 1978
4. Slippages
5. Done
6. Months

Distribution of Jobs within EDF's Equipment Division

The Equipment Region to which the Division assigns the responsibility for building a power plant (this is the "Operational Region" for this plant) is responsible for carrying out or for guiding the studies for the specific part of the project and for managing contracts for this (the civil engineering contract is the largest of these).

Studies for the standard part, its possible modifications, and management of contracts (for construction done in factories) related to this are the responsibility of the Pilot Region, whose activities cover all the sites concerned.

The five regions of the Equipment Division are involved in the 900 MW program:

a. The Clamart Region: Fessenheim power plant;

b. Alpes-Lyon Region: Bugey power plants (the Operational Region and the Pilot Region functions are combined for these two operations);

c. Alpes-Marseille Region: Operational for Tricastin and Cruas. Pilot for part of the standard CP 1 (nuclear block with the exception of the nuclear annex building and miscellaneous facilities);

d. Paris Region: Operational for Gravelines and Blayais. Pilot for the second part of the standard CP 1 (nuclear annex building and machine room, essentially);

e. Tours Region: Operational for Dampierre, Saint Laurent, and Chinon. Pilot for the part of the project specific to the CP 2 type (essentially the machine room).

The five regions work in close relation with the two staff services, SEPTEN [Thermal and Nuclear Research and Plans Service] and SCF [Manufacturing Control Service].

The current status of the entire 900 MW level is briefly presented below. All of the features which form part of this record are organized under six headings: procedures, studies, civil engineering, construction of equipment in factories, assembly and installation at the site, and testing and start of service.

The Fessenheim power plant, the first one in the series, whose two segments are now operating at 100 percent of their power, has already supplied over 100 billion kWh. This plant, of course, occupies a special position. A first operating record covering a significant period is now possible. This is given in an article in this issue by Messrs Leblond and Ferriole.

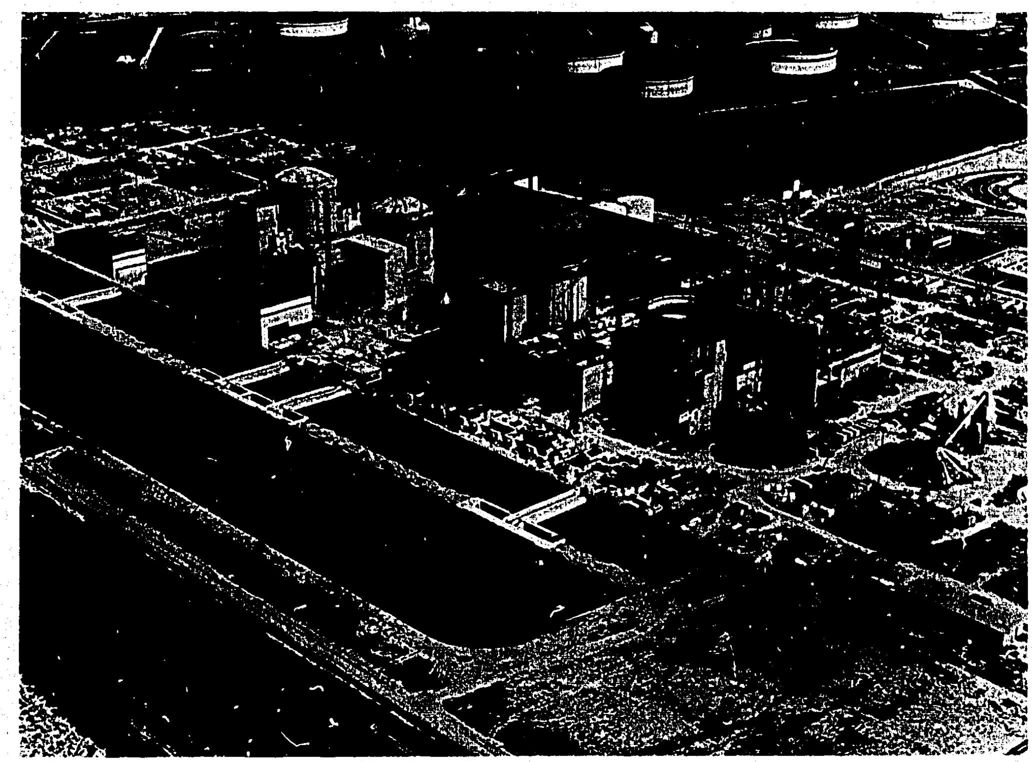
I Procedures

The public utility of all the operations of the 900 MW level (nine sites) has been recognized by successive decrees. Most of the sites needed have been purchased on friendly terms, and now there are just a few very limited problems remaining concerning site availability.

At the end of the creation authorization procedure -- which includes a detailed examination of the preliminary safety report by the Standing Group on Reactor Safety, the creation authorization decisions for Bugey, Tricastin, Gravelines, Dampierre, Blayais 1-2 and Saint Laurent were made in succession by the prime minister. The preliminary safety reports for Chinon, Blayais 3-4 and Cruas are now being examined by the standing group.

The ministerial authorization process for loading and functioning tests -- including examination by the standing group, based on the report of the IPSN [Nuclear Protection and Safety Institute], of the lengthy provisional safety report, including the provisional operating regulations -- has been completed for Bugey 2-3 and has begun for Bugey 4-5, Tricastin, Gravelines, Dampierre, and Blayais 1-2 (the latest reports were filed at the end of 1978).

The process opening a new ministerial authorization for the definitive start of service, including the completion and examination of the definitive safety report completing the provisional report, has been begun for Fessenheim and for Bugey 2-3, The authorizations for intake and discharge of water, which list in particular the standards to be respected about heating the water, have been obtained for the Fessenheim, Bugey, Tricastin, and Blayais 1-2 plants. The same is true for the authorizations for the discharge of liquid and gaseous radioactive effluents for Fessenheim, Bugey, and Tricastin. The conditions set for this discharge, which are determined by ministerial decisions, were recently made for the latter two and are much more restrictive in nature than the one used for the segment execution studies; this will therefore require the use of additional facilities.



The Gravelines Power Plant (August 1978).

## II Studies

At the point where things are now, design and planning studies and the essentials of the studies needed for execution have been completed both from the point of view of the prime contractor and research offices which are working together and from the point of view of the builders.

Along with this, a major research followup program is accompanying the execution, thus making use of the experience acquired during construction and during the first tests and start of service; this has led to a significant amount of modifications made in the plans and in the facilities. This should significantly decrease after the start of service of the first few segments.

Then we should mention the studies now in progress:

a. Work on the general functioning tests, with special attention being given to loading tests (functioning with control rods of a special type called "gray rods");

b. Studies related to manufacturing anomalies in equipment and constructions; these studies are done to determine the acceptability of developments which do not strictly conform to the original instructions, and include remedies to be used.

c. Special safety and radiation protection studies done in relation with the standing group (these deal in particular with the effects of earthquakes and certain equipment failures);

d. Some research and development activities involving fuel, etc.

## III Civil Engineering Work

The civil engineering work for the nuclear segments, a complex program considering the high concentration of the work, was discussed in an article by Messrs Cousyn and Goubin which appeared in a previous issue of REVUE GENERALE NUCLEAIRE (issue no 3 of 1977). The magnitude of the work to be done can be seen from the following information for the Cruas power plant, the last in the series (four segments separated by 6-month intervals).

| | |
|---|---|
| Concrete | 550,000 $m^3$ |
| Steel | 70,000 tons |
| Casings | 1,000,000 $m^2$ |
| General clearing and earth work | 1.2 million $m^3$ |
| Removal of sand and gravel for fill and concrete | 3.2 million $m^3$ |
| Maximum workforce | 1,800 workers |

These figures do not include the four atmospheric cooling towers (100,000 $m^3$ of reinforced concrete, approximately).

The civil engineering work for the entire 900 MW level is very well advanced now. It has been completed for the Bugey power plant and the essential part of the heavy construction work is about to be completed for the Tricastin, Gravelines, and Dampierre power plants. At the Cruas construction site, where work started in October 1977, the first concrete was poured in July 1978 and work on the leakproof wall, which precedes the excavation for segments 3 and 4, the last pair of the 900 MW level, will begin soon. The end of the heavy construction work is scheduled for mid-1982 (4 years of concrete work).

Considering the matter in greater detail, the situation at each of the sites is as follows.

Tricastin

By the end of October 1978, 443,000 $m^3$ of concrete of a total of 455,000 $m^3$ had been poured. The prestressing of the reactor buildings of segments 3 and 4 and the end of the concrete work on the dome for the reactor building of segment 4 are being done now. The metal framework and covers of the machine room are about to be completed and all the major handling mechanisms are operational. The secondary frames and the larger wooden constructions have been done at the rate of 100, 70, 50, and 15 percent, respectively, for the four segments. The smaller woodwork and painting are also proceeding well.

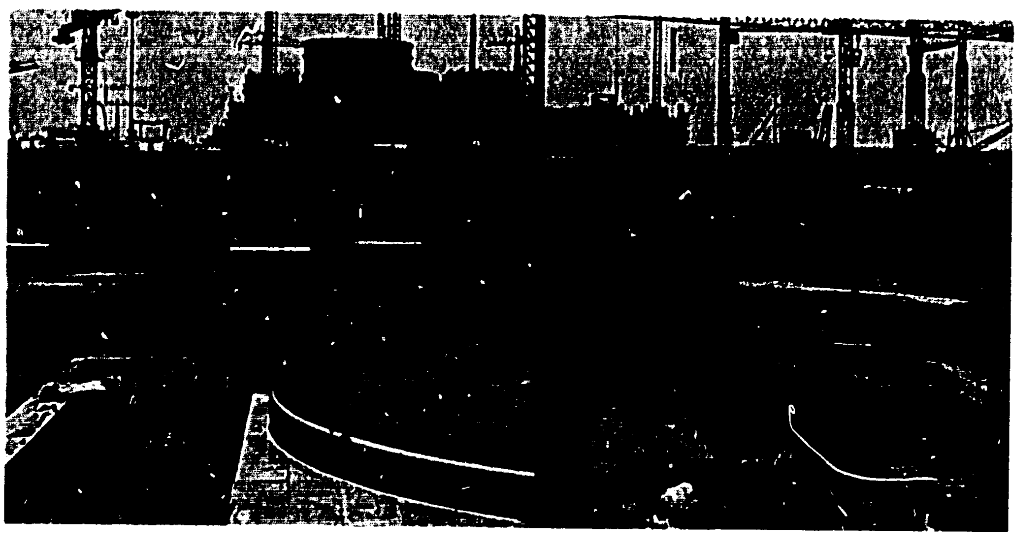
Gravelines

At this site, the situation is almost identical with the situation at Tricastin. By the end of October 1978, 451,000 $m^3$ of concrete had been poured of an estimated total of 465,000 $m^3$. The prestressing of reactor building no 3 is being done, the concrete work on the dome for segment 4 has been started, and the machine room should be completely enclosed during December.

At this site, built partly on an area that was formerly under seawater, the excavation work (3,000,000 $m^3$) was preceded by the pouring of a fill of 7,000,000 $m^3$ of sand taken from the new entry to the port of Dunkerque.

Dampierre

Here, where the work is about 5 to 6 months behind Tricastin and Gravelines, 370,000 $m^3$ of concrete had been poured by the end of November 1978 (excluding cooling structures), of an estimated total of 380,000 $m^3$, and layoffs of construction workers have begun. Still to be done is some concrete work for the nuclear block of 3-4, especially the dome of segment 4, as well as the concrete work for the upper part of cooling tower no 3 and the entire cooling tower for no 4 (total volume of concrete used for the cooling structures: 120,000 $m^3$), plus the cover for the machine room of segment 4.



Le Blayais Power Plant Construction Site (June 1978).

Saint Laurent B

The earth work (3.2 million $m^3$) has been completed and the concrete work for this pair of segments is approximately 90 percent complete (180,000 $m^3$ of a total of 200,000 $m^3$). The dome of the second segment was put in place in October.

Machine room 1, whose main frame is completed and whose moving crane is operational, was turned over to the builder of the turboalternator group on 15 September. The hoisting of the deck for machine room 2 was done in October. The construction of the two atmospheric cooling towers will be finished soon.

Le Blayais

The nature of the foundation soil (mud unable to support such structures) required a major excavation job (2 million $m^3$ of mud removed to a depth of 15 m) and the pouring of a sandy fill taken from the Gironde and built up on the stronger subsoil under the mud (5.2 million $m^3$). The edges of the two excavation pits were stabilized by building a large concrete wall with braces, poured in the soil, then anchored in it after dredging of the mud (2,000 m of wall, 30 m in height).

All this work is now finished for both pairs, and the concrete work is 50 percent completed (240,000 $m^3$ of a total of 480,000 $m^3$).

The dome of segment 1 was put in place in November 1978; the dome of segment 2 is scheduled to be raised in April 1979. As for the machine room for 1-2, work on the main frame for the machine room began in September 1978, and the moving cranes were raised in November (see Figure 1, Work and Test Program).

Chinon

With the exception of the type of atmospheric cooling tower, this plant with two segments of the CP 2 type is practically an identical repetition of the Saint Laurent plant, with a target date 1 year later. The target date is in fact less, since for the main part of the construction, 138,000 $m^3$ had already been poured at the end of November 1978 (68 percent). The dome of segment 1 was to be put in place in January 1979 and the start of the frame of the machine room is to be done in April 1979.

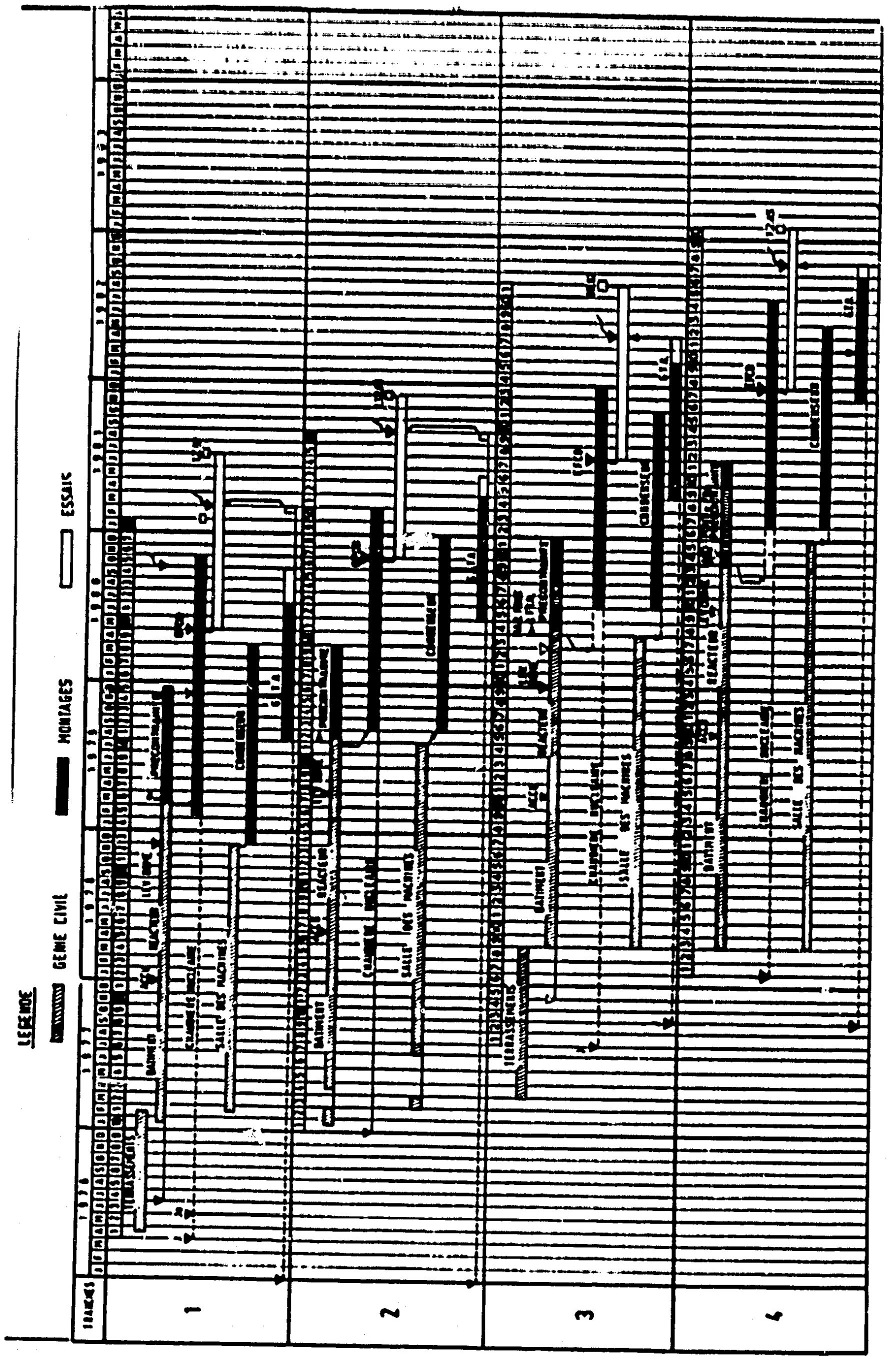



Figure 1: Blayais A Power Plant: General program 4 x 900 MW -PWR.

Key for Figure 1:

1. Legend
2. Civil engineering
3. Assembly
4. Tests
5. Segments
6. Earthwork
7. Building
8. Bunker
9. Reactor
10. Raising of dome
11. Prestressing
12. Nuclear boiler
13. EFCO [Open Tank Functional Tests]
14. Machine room
15. Condenser
16. GTA [Turboalternator group]

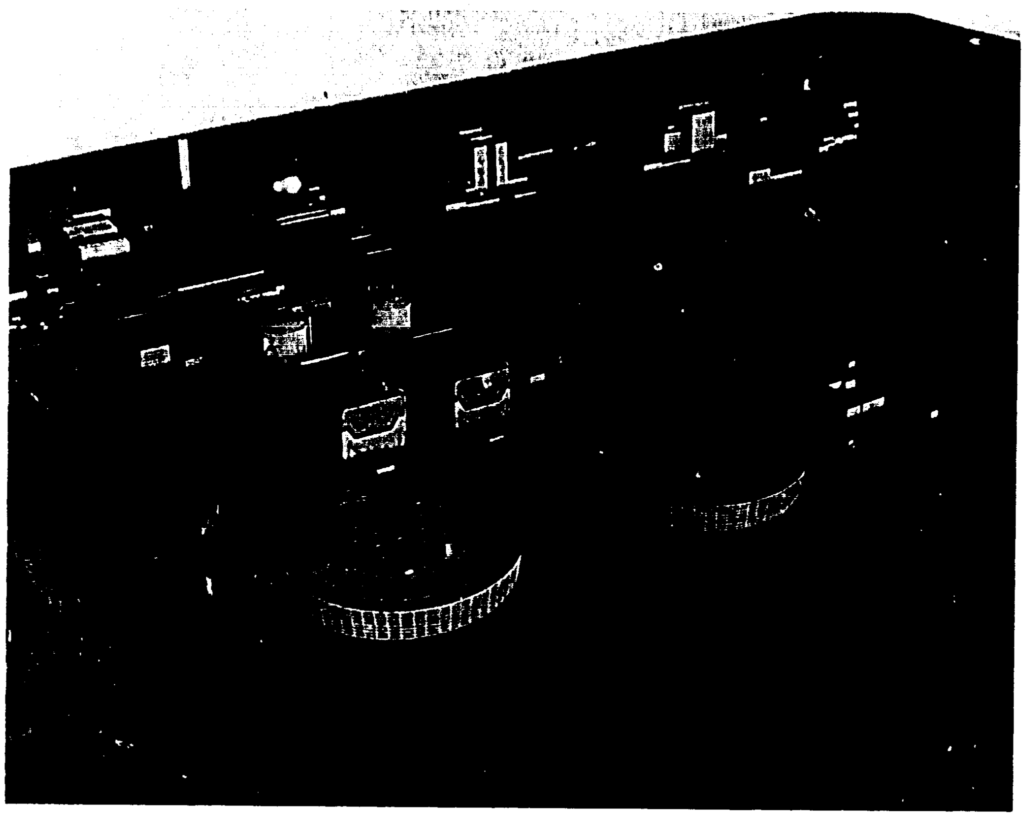
Cruas

The volume of work for this power plant, the last of the 900 MW level, has already been given earlier. A year into the work, the general clearing and earthwork are now being completed (1 million $m^3$ at the end of November), the river borrow pits for alluvial materials are over 1/3 done (1.3 million $m^3$), the concrete work on the apron supporting the neoprene studs for the 1-2 pair and the peripheral wall attached to it are largely done, and the concrete pouring of the nuclear block itself should start in December.

## IV Construction in Factories

Equipment for the 900 MW level is covered in contracts betweeen EDF and the builders; most often these contracts are for series of identical equipment for several segments ("level" contracts), and if necessary, they also cover assembly at the appropriate site. We should mention here that while the Fessenheim and Bugey power plants had specific contracts for each one, the equipment for the nuclear blocks for all of the CP 1 and CP 2 segments (24 units) is handled in the same series of contracts, each covering all the equipment to be manufactured and assembled. The same is true of equipment for the machine rooms of the CP 1 type (16 segments) and of the CP 2 type (eight segments).

After the inevitable problems, delays, and changes that are always part of a job of such a scale, manufacturing is now proceeding in satisfactory conditions and at a suitable pace. This situation does not in any way exclude the possibility of construction incidents of a random nature, which are called "manufacturing anomalies." These demand constant vigilance on the part of the builder and the contractor, naturally to detect them, but also to evaluate carefully their real significance and to determine the appropriate corrections.



Model of the Chinon Site with the Two PWR Segments.

In this short article, there can be no possibility of giving details on the status of the manufacturing of the many pieces of equipment for the 900 MW level. There are hundreds of contracts betweeen the various regions of the Equipment Division and the builders. We will only give briefly the situation for the nuclear boilers and turbo-alternator groups, which is quite characteristic of the overall situation.

Nuclear Boilers -- Built by FRAMATOME

The output rate of the tanks and steam generators, whose installment in the reactor buildings now controls the essentials of the on-site assembly in the nuclear blocks, in practice governs the programming of all the assembly work of the boilers and thus of the completion of the 900 MW level to a great extent. Seven CP 1 tanks will have been supplied by the end of 1978, after the six Fessenheim and Bugey tanks. Ten tanks are to be delivered in 1979, from Gravelines 3 to Chinon B1; three in 1980, two in 1982, and two in 1983. Gradually the tanks being built for export and for the 1300 MW level will replace the production of those for the French 900 MW level in the builder's plants.

For the first eight CP 1 segments, the primary tubing and steam generators have been delivered to the site and have either been installed or are being installed now. The steam generators, which so far have come from the factory in two sections and then been assembled on the site -- for Fessenheim and Bugey -- are now, at least in part, delivered in a single unit; the design of the reactor building makes this possible for the CP 1 and CP 2.

We should also mention that the nuclear fuel produced in the FBFC /expansion unknown/ plants (a FRAMATOME subcontractor) at Dessel and Romans is being delivered in the required periods of time (deliveries for the Bugey 5, Tricastin 1, and Gravelines 1 segments during the first quarter of 1979; the fuel for Dampierre 1 is already being sent to EDF's interregional storage facility at Chinon).

Turbo-Alternator Groups of the CP 1 Type -- Built by Alsthom-Atlantique

All the parts for the first four Tricastin 1, Gravelines 1, Dampierre 1, and Tricastin 2 segments have been delivered and installed, or are in the process of installation now: the HP /High Pressure/ and BP /Low Pressure/ internal and external casings, exhaust enclosures, HP and BP rotors, HP and BP intake units, HP and BP guides, alternator stator and rotor, dryers, superheaters, etc. Deliveries for the following segments are well underway, and all the rest of the equipment for this impressive series of 16 identical machines is at different stages of development: being manufactured in the foundry, forge, mechanical welding, or milling shops of the builder and of the numerous French and foreign subcontractors and suppliers.

Saint Laurent des Eaux: Construction of Two PWR Segments (May 1978).

CP 2 Type Turbo-Alternators -- Built by Alsthom-Atlantique

These systems, based on CEM /Electro-Mechanical Company/ technology, differ from the preceding by the number of BP turbine rotors they have, which have been reduced from three to two. The preliminary tests are now being done by the builder, and the first equipment should be sent soon to the Saint Laurent site. For the later segments, production is continuing without any major problems, often in advance of the site schedules. Deliveries of the main parts for the turbines (BP shafts and intake frames) and alternators (body, rotor) for the last segments of the 900 MW level (Cruas) are already being made.

V Installation and Assembly Work

The installation and assembly work for a nuclear power plant has also been discussed in an article by Messrs Rouzaud, Baudriller, and Lagarde, which appeared in REVUE GENERALE NUCLEAIRE in 1977 (issue no 3).

The installation work is practically completed at the Bugey site; its first two segments are now connected to the electric power network (on 10 May and 21 September 1978, respectively). The third segment should be connected in March 1979 and the fourth in July 1979. Aside from the work in progress on Bugey 4, the only remaining work consists of a few additions and modifications which have been found to be of use. This work will be done during the first shutdown for refueling.

Equipment installation is now well underway at Saint Laurent and is beginning at Blayais, where the air conditioning and general electrical contractors are now working, installing air conditioning ducts and electric boxes and panels, MT /Medium Voltage/, BT /Low Voltage/ transformers in the electrical building and the control room, and auxiliary tubing for the nuclear boiler or for all of the nuclear annexes. A certain amount of heavy equipment was placed in the buildings before completion of the civil engineering in order to simplify handling procedures and limit or eliminate the need to provide temporary access passages (bunkers, tanks, exchangers, etc.).

This is the major part of the work now in progress at Tricastin, Gravelines, and Dampierre, where nearly 2,000 workers are employed at each site, and whose 12 segments are to go on line in less than 2 years (from mid-1979 to mid-1981).

At both Tricastin and Gravelines, segments no 2, whose work is at identical stages, a little behind Bugey 5, the primary circuit is now completely installed and the prescribed complete hydraulic testing (225 bars) was done in early November 1978. By the end of November, the installation of the auxiliary nuclear tubing of the boiler was almost completed and some modifications decided on in the last few months were being incorporated. There is some concern about the installation of the secondary tubing for all the nuclear annexes, for there is a great deal of work to be done on modifications, and this may cause some delay in meeting the target date for connection in July-August 1979.

The installation of the turbo-alternator groups is in advance of the nuclear boiler work.

On the following segment, Dampierre 1, scheduled to go on line in November 1979, the welding of the main primary circuit of the boiler has been completed and it is now being connected to the last secondary circuits which are attached to it. The status of the assembly of the tubing of the auxiliary circuits (of the boiler -- 80 percent by the end of November 1978; of all the nuclear annexes -- 85 percent completed) and that of the control-command electrical systems and the general electrical system is close to the point required for the start of operations to fill the tank and the EFCO /Open Tank Functional Tests/, which mark the start of the period of major systems testing.

The installation of the turbo-alternator group has reached a phase where the first mechanical rotation tests can be done in February 1979, and a first connection to test steam can be made (the first of the CP 2 series, as the Dampierre site has a steam generating facility using oil) in May 1979.

At segments no 2 at both Tricastin and Gravelines, for which the start of the EFCO are scheduled for approximately March 1979, the tanks and steam generators are installed and the welding of the main tubing connecting them is well advanced. It is the installation of the auxiliary tubing and of the electrical circuits which is now at a critical point, and great efforts are being asked of the builders who are employing hundreds of tubing assemblers and electricians at each site.

At the group consisting of Dampierre 2, Tricastin 3, and Gravelines 3, about 6 months behind the preceding group, the welding of the primary circuit is now going on. At Gravelines 3, a new operations sequence had to be used because the tank will not arrive at the site until January 1979. The installation of the auxiliary tubing and of the control-command electrical circuits and of the general electrical system is well underway at Dampierre and has been begun at Tricastin and Gravelines.

Work is beginning on the following segments: Tricastin 4, Dampierre 3, Gravelines 4, and Dampierre 4; their tanks should leave the factory between March and August 1979.

VI Testing and Start of Service

The first two Bugey segments (2 and 3) went on line on 10 May and 21 September 1978. At the end of November 1978, the maximum power came to 87 percent of normal power for Bugey 2 and 75 percent for Bugey 3. During the increase in power, the plant had several shutdowns for a variety of reasons, and so this power increase took longer than expected. The following problems were encountered:

a. Mechanical incidents: in particular, the alteration of some of the condenser's tubes;

b. Modifications of some equipment, based on the experience at Fessenheim (dryers and superheaters, etc.).

c. External events, primarily high levels of muddy water in the Rhone;

d. Problems of a social nature -- strike of operating personnel.

At segment 4, whose connection is scheduled for March 1979, all of the tests before fuel loading have been done. Fuel loading should start in early January 1979. Connection of the turbo-alternator group to test steam was done on 15 June 1978.

At Bugey 5, Tricastin 1, and Gravelines 1, the overall tests of the boiler, which take approximately 10 months preceding the first connection, were well underway at the end of November. The filling of tanks and the EFCO, which mark the start of these tests, began at the end of the third quarter of 1978. The cold tests and testing of the primary circuit under pressure have now been completed at the three segments, and operations will proceed slightly differently at each of them. The schedule given below is for Tricastin 1:

a. Tests of the crane for handling fuel under water;

b. Resumption and end of EFCO;

c. Completion of initial checkout (in accordance with provisions of decision of 26 February 1974);

d. Placing of internal parts with instrumentation in tank;

e. Test of seal of containment enclosure (4 bars);

f. Hot tests of primary circuit;

g. Loading of fuel, previously placed in the pool of the fuel building;

h. Precritical tests both cold and hot;

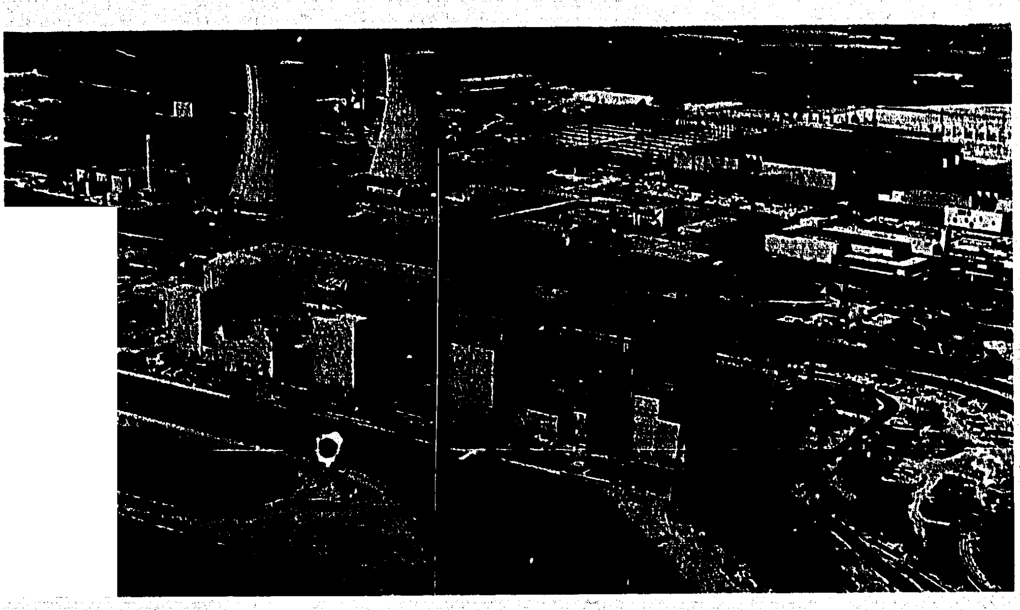
i. Going critical and being put on line.

The successful completion of these test programs will give EDF eight additional operational segments of the 900 MW system for the winter of 1979-1980.

A new and large group of six segments will be added to the preceding for the winter of 1980-1981: Dampierre 1 and 2, Tricastin 2 and 3, Gravelines 2 and 3. Of these segments, phases 1 and 2 of the tests, which precede the phase of major system testing, and whose contents, described very briefly below, are given in an article by Messrs Broch and Cayol (REVUE GENERALE NUCLEAIRE no 3 of 1977), are now more or less in progress.

Phase 1

Last checkout of end of installation, preliminary tests and tests of start of service of isolated components. For example: hydraulic tests, checkout of relays while unconnected, tests of pumps with zero flow, etc.



Tricastin Power Plant and Eurodif Cooling Towers (June 1978).

Phase 2

Tests of integrated components or of functions which require functioning configurations which can only be done during partial system tests.

Each of the "elementary systems" of the plant has a series of specific tests which are carefully defined in the test procedures. These tests are designed to check that the system can function correctly in all normal or accidental situations either expected or imagined at the design phase.

All these operations take place as soon as the installation and assembly status permits; each group of equipment or systems moves in succession from the "assembly area" to the "test area," in which any intervention requires the use of very strict procedures, as the system is then connected to fluid or electrical power sources.

Phase 3

Major system tests, whose nature and sequencing have already been given.

Table II: Expenditures Listed as of 30 September 1978 for Each Pair of 900 MW Segments. Given in Percentage of Total Cost.

| Tranches | % du coût total |
|---|---|
| Fessenheim 1-2 | 92,2 |
| Bugey 2-3 | 89,0 |
| Bugey 4-5 | 78,4 |
| Tricastin 1-2 | 76,8 |
| Gravelines 1-2 | 73,4 |
| Dampierre 1-2 | 71,0 |
| Tricastin 3-4 | 50,5 |
| Gravelines 3-4 | 45,0 |
| St-Laurent 1-2 | 46,4 |
| Dampierre 3-4 | 39,6 |
| Le Blayais 1-2 | 36,3 |
| Chinon 1-2 | 22,6 |
| Le Blayais 3-4 | 14,0 |
| Cruas 1-2 | 2,8 |

Key:

1. Segments
2. Percentage of total cost

To conclude at the end of this short presentation of the status of construction of the 900 MW PWR power plants (see Table II, percentage of expenditures for each pair), perhaps we should again mention the delay in the nuclear program and discuss it in terms of its true significance. The few elements presented in this article, while they do of course reveal the slippage between the original schedule (set to accelerate the start and "running in" phase of industrial systems) and the real situation at the end of 1978, will enable the reader to measure the work done now and to conclude, we think, that the nuclear program with its goal of 1985, as defined by the government in 1974, is now well under way towards completion.

The result of joint action by hundreds of builders, research offices, EDF's and government's contractor services, this program in the years to come will bring about a profound change in saving our resources used for producing electrical energy, and will thus make a big contribution to the development of the diversification of the primary energy sources, which is a vital necessity for our national economy.

## Fessenheim Nuclear Power Plant

Paris REVUE GENERALE NUCLEAIRE in French Dec 78 pp 460-470

/Article by Andre Leblond, chief of the Fessenheim power plant, and Guy Ferriole, chief of the general research division of the production-transport office, thermal production service of EDF/

/Text/ After presenting the essential features of the Fessenheim power plant and the phases of its construction and start of service, the authors discuss the start of service tests and the problems encountered. They analyze the main results obtained and draw attention to the lesson that can be learned from this experience.

The Fessenheim nuclear power plant will have supplied in 1978 -- its first year of industrial operation -- over 11.5 billion kilowatt-hours to the French electrical power system. This is over 40 percent of the electrical energy of nuclear origin produced in France during 1978.

This excellent result is even more significant and promising as the two segments of this power plant are the first of a series of facilities which, in the years to come, are to provide the basis for electricity production in France: the history and record of this first proving ground are thus of great interest.

### I General Panorama

The Fessenheim power plant, built on the left bank of the grand canal of Alsace, has two segments each with a net electric power of 890 MW.

Each segment has a nuclear boiler of the PWR type supplying steam to a turbo-alternator group.

These boilers consist of a 2,660 MW (thermal) reactor which transmits its thermal energy to three steam generators. This is done by circulating water under pressure by three pumps called "primary pumps."

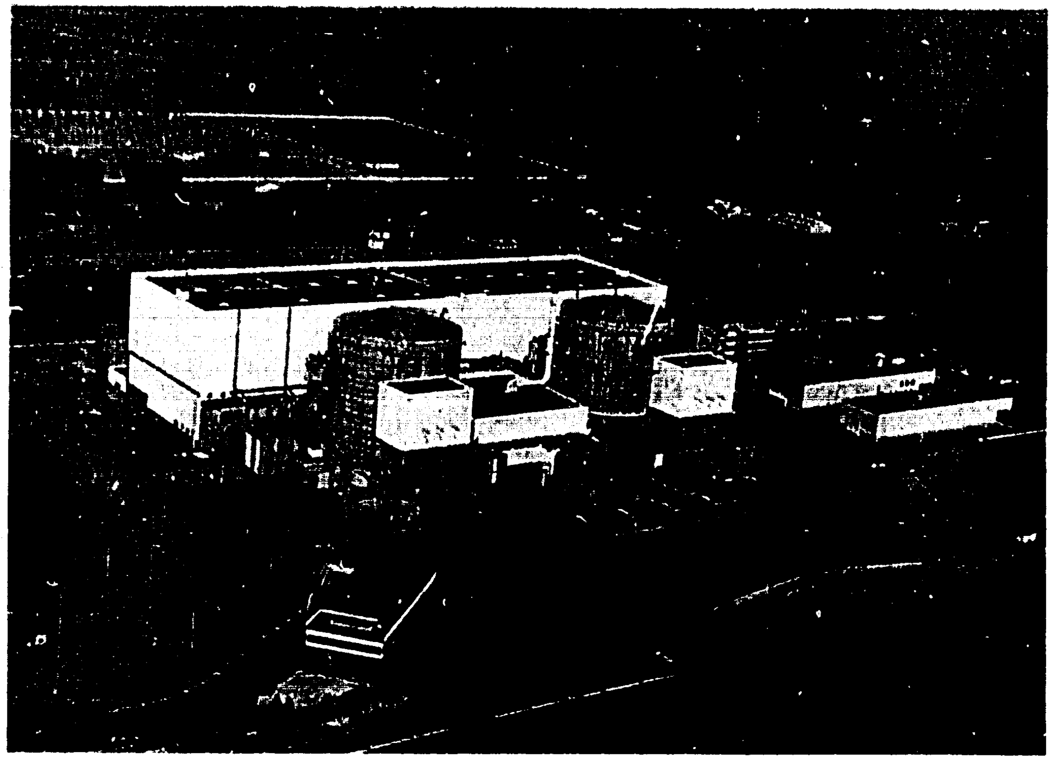
The essential characteristics of the most important equipment are given in an annex, along with a transversal view of the power plant and a schematic of the circuitry.

The main phases of construction and of the start of operations were the following:

| | | |
|---|---|---|
| a. Decision to build | | 1970 |
| b. Installation of the reactor tank | Segment 1: | October 1974 |
| | Segment 2: | January 1975 |
| c. Hydrostatic testing of primary circuit | Segment 1: | March 1976 |
| | Segment 2: | October 1976 |
| d. First loading of fuel | Segment 1: | December 1976 |
| | Segment 2: | March 1977 |
| e. First connection of alternator to network | Segment 1: | 6 April 1977 |
| | Segment 2: | 7 October 1977 |
| f. Full power | Segment 1: | October 1977 |
| | Segment 2: | February 1978 |
| g. Start of industrial service | Segment 1: | December 1977 |
| | Segment 2: | March 1978 |

The construction period was disrupted by a change of option concerning the type of fuel (change from a 15 x 15 pencil system to a 17 x 17 system, in order to have the same flexibility as the other 900 MW segments which will follow), by manufacturing problems, by one act of sabotage, and also by stiffened regulatory requirements.

Concerning the actual start of operations of the equipment and circuits, this covered a period of nearly 3 years, from the first testing of annex functions (production of water, of compressed air, or auxiliary power supply) until the start of industrial service of the largest contracted system, the nuclear boiler.



Fessenheim Power Plant (August 1978).

Industrial operation began in January 1978 for segment 1 and in April 1978 for segment 2; it is now continuing in very satisfactory conditions. The first term of this operation will come with the shutdown of each segment in 1979 for 4 months, in order to replace a third of the fuel and to make many required checkouts (associated with this first shutdown and with the 10-year review); this shutdown will also be used to make additions to the equipment, modifications, repairs, preventive investigations, etc.

The following remarks will concentrate most on the most recent periods, particularly the period starting with the first connection of the segments to the network; then we will examine:

a. Start of service testing: its goal, contents, and how it was conducted;

b. Problems encountered;

c. Main results obtained;

d. What was learned from this.

II Goals and Organization of Tests

The start of service tests were divided into three phases:

The first phase preceded the hydraulic testing of the primary circuit of the boiler. In addition to the preliminary tests, it included the gradual start of operation of equipment and circuits; this phase ensured that the circuits and their control and command equipment were capable of functioning, without heat, according to the design specifications.

The second phase (5 to 9 months) tested the circuits in their entirety, first cold and then hot, in conditions as close as possible to normal operating conditions. This period came to an end with the first loading of fuel into the reactor.

The last phase (about 10 months) included:

a. Precritical tests, both cold and hot, and in particular including monitoring of the functioning of the control rods;

b. Physical tests at low power, designed to check the neutron characteristics of the core;

c. The increase in power after electrical connection of the alternator to the network. During this period characteristics of the core at different power levels and the capability of the facilities to withstand power spikes, either normal or incidental, were monitored. It had to be ascertained:

1. That in case of a partial or complete loss of a function, the facility was protected and if necessary could be restored to a safe condition;

2. That the hypotheses used in calculating accidents and limits of operation did include sufficient margins.

III Conducting the Tests

All these tests were conducted under the authorization and control of the SCSIN [Central Safety Service for Nuclear Facilities] after consultation with experts from the Standing Group on Reactors.

About 40 meetings of the standing group were held; these meetings were preceded by about 50 preparatory sessions, before obtaining the authorization for loading fuel into the first segment; this was then followed by authorization for precritical hot tests, for going critical, and for tests at 50 percent power, then at 100 percent of the nominal power.

At the time of the first connection of the turbo-alternator group, the boiler had already operated at about 20 percent of its nominal power, with the steam produced being vented directly to the condenser by a turbine bypass circuit.

At each level of power which followed (30, 50, 75, 90, and 100 percent), the following major tests were carried out:

a. Survey of functioning conditions;

b. Charting of neutron flows in the core;

c. Tests of regulations;

d. Power variations.

The analysis of tests done at one power level determined the possibility of increasing the power to the following level.

The diagram showing daily power (Figure 1) illustrates the chronology and duration of these tests, which were disrupted by a certain number of incidents. Between the first connection and functioning at nominal power, the duration of tests or work was 204 days for the first segment and 142 days for the second. An ideal duration is about 80 days.

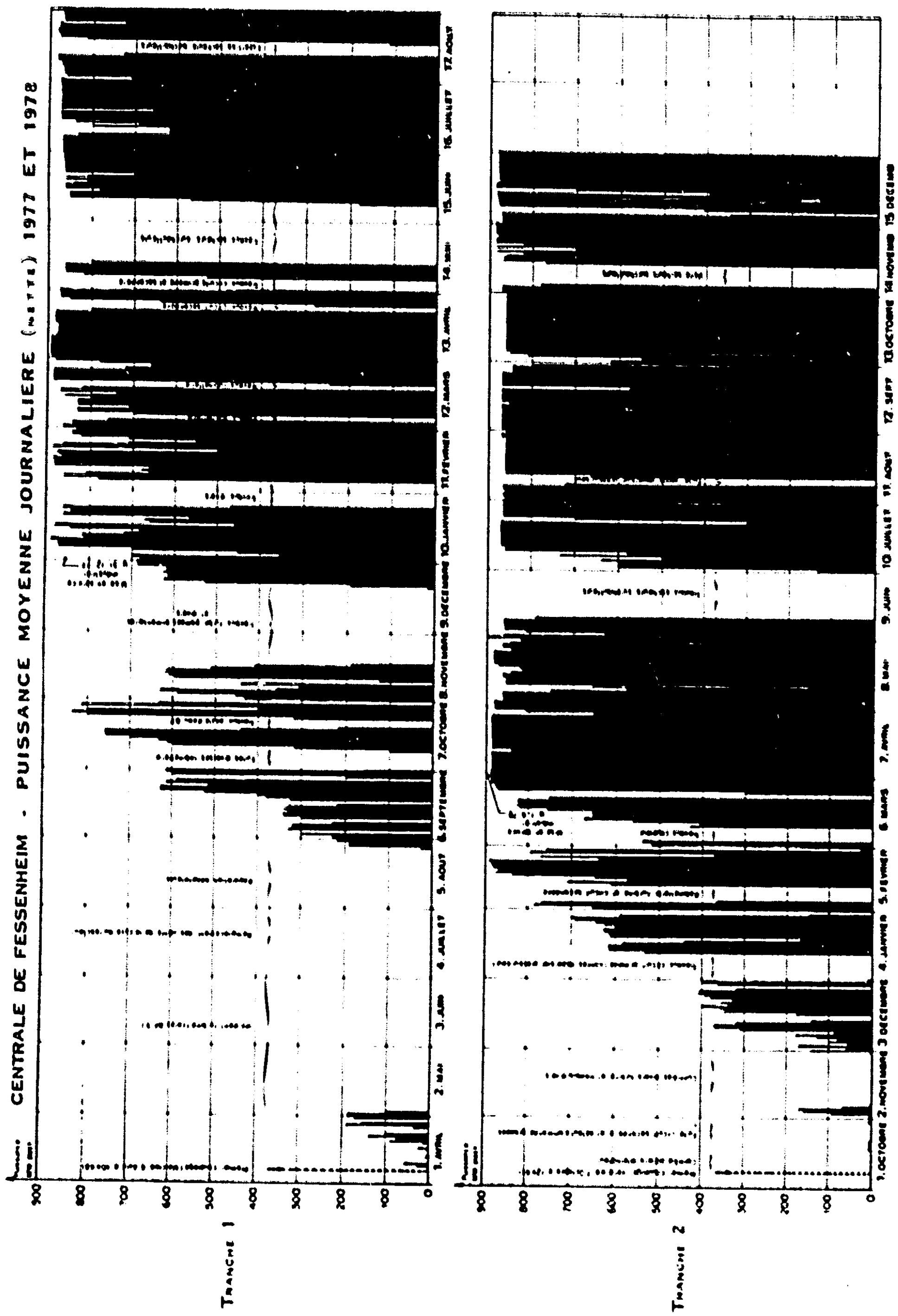



Figure 1: Fessenheim Power Plant: Average Daily (Net) Power 1977 and 1978

Key for Figure 1:

1. Segment 1
2. Power in MW of electricity
3. First connection (Wednesday, 6 April at 1048)
4. Turbine incident (low pressure case 3)
5. Replacement of connections in reactor tank
6. Repair of adapters
7. Miscellaneous plumbing leaks
8. Work on low pressure water station
9. Work on feed turbopumps and miscellaneous work
10. Start of industrial service on 31 December 1977
11. Miscellaneous work
12. Work on secondary circuit
13. Work on primary and secondary circuits
14. Work on dryers-superheaters
15. Checkout of dryers-superheaters
16. Segment 2
17. First connection (Friday, 7 October at 1240)
18. Check of alternator bearings
19. Leak in secondary circuit and defect in cluster command
20. Various checks of turbine and miscellaneous work
21. Work on primary circuit (pressurizer spray valve)
22. Turbine plumbing and secondary circuit plumbing
23. Work on connectors
24. Start of industrial service on 1 April 1978
25. Work on dryers-superheaters
26. Leak in pressurizer spray valve
27. Check of dryers-superheaters

The following information can be drawn from this phase preceding industrial functioning and from the actual start of service testing itself:

a. Generally speaking, unlike the majority of thermal power plants for which full capacity is reached quickly after the first connection, the rise in power of a nuclear plant of the PWR type necessarily takes a long time.

b. Considering the site aspects, the experience with starting the first segment greatly accelerates the speed of starting service at the second.

## IV Problems Encountered

We should say first of all that the two segments are identical and entirely independent except for the effluent treatment facility which is shared, and also that they are the first of a series.

Of the equipment for the nuclear boiler, the major equipment was built under license. Most of the rest of the equipment is being put to a new use in this type of facility. The major pieces of equipment of the secondary part are prototypes, and the effluent treatment equipment is entirely new in its functioning conditions.

Among the problems since the first connection, we should mention those with a significant incidence on the duration of tests or on plant operating time.

For segment 1, listed in chronological order, these were:

1. An incident affecting the turbine on 2 May 1977 while the segment was at 30 percent of nominal power; serious damage of a stationary guide of a low pressure casing, probably caused by a manufacturing defect, required changing all the clearances between wheels and guides, checking all the low pressure casings, and replacing guides exceeding tolerances (10 weeks).

2. A leak which appeared in mid-July between the reactor tank and its cover; this required the replacement of two connections and the modification of the closing bearing (20 days).

3. The discovery at the end of July 1977 of a weakness in the seal of the welding on the control rods command mechanism housing located on the reactor cover; a complete checkout of the areas involved uncovered several defects of the same type (20 days).

4. At the end of October 1977 damage was found on one of the two turbopumps feeding the water station after contacts between the drum and the gland rings; the damaged pump was replaced and the second pump was modified during a 1-month shutdown in November-December scheduled for other reasons.



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100040062-8

5. During the November-December shutdown, six steam blowout balloons surrounding the turbine and placed in the condenser were modified; these had ripped because of a design defect.

In all, the incidents related to the prototype nature of the secondary part of the facility and the work done on the tank connections caused a 112-day delay in getting the segment to its operation at nominal power; if these problems had not occurred, this power would theoretically have been reached 92 days after the first connection.

Furthermore, all throughout this period, the prescribed requirements on methods of disposing of liquid effluents in the environment have become more and more restrictive, and this caused some problems, even including interrupting the schedule.

The authorizations for waste disposal -- controled by the SCPRI /Central Protection Service against Ionizing Radiation/ -- require that all effluents, whether slightly or highly radioactive, be retained and monitored before removal. This requirement has affected the continuing secondary draining of the steam generators, done in order to obtain and maintain very strict chemical characteristics of the water; this is important to keep the equipment working for a long period of time. At the time of design, it was felt that these effluents could be disposed of directly.

After the start of industrial service, the only incidents affecting the satisfactory functioning of segment 1 were:

1. A leak in a valve of an auxiliary circuit of the boiler; the motor of a primary pump had to be replaced (6 days).

2. The deterioration of internal parts of the four dryers-superheaters associated with the turbo-alternator group (inspection doors on the separation plate between intake and outlet of heating steam on two of them, protective bulbs for the tubular bundles on all four); the duration of shutdown for this was 37 days (including 5 days for checking repairs after 2 months of operation).

There have also been some shutdowns caused primarily by defects in the tightness of some of the plumbing, although all the shutdowns for other reasons were used for repairs. The incidents first affected the primary and secondary circuits, then mainly the secondary circuit (external leaks, weak internal seal, rupture of rod, blockage). The total time lost, either totally or partially, caused specifically by plumbing problems amounts to the equivalent of 15 days of shutdown since the first connection.

For segment 2, the experience acquired with segment 1 did make it possible to do a certain amount of work before its first connection (modification of low pressure cases of the turbine, repair of the welding on the cluster command mechanism). Causes of delay or time lost were roughly the same as in segment 1. The main occurrences to be mentioned are:

1. Total loss of function for 10 days because of heating of a bearing of the alternator and a defect in a control cluster command device;

2. A 3-week shutdown in November 1977 to do some work similar to the work done in segment 1 at the same time, primarily on the secondary part of the facility (blowout balloons near the turbine, plumbing work, checkout and repair of feed turbopumps);

3. An internal defect in the circuit breaker at the outlet of the alternator (6 days);

4. Replacement of a prototype adjusting valve on the turbine steam intake (6 days);

5. Work on dryers-superheaters after the incident in segment 1 (25 days);

6. Several short duration shutdowns required by plumbing failures (35 days).

V First Reports

Considering the "first of a series" and partially prototype nature of the two segments, the first operating period has been satisfactory.

Of all the technical problems encountered, none has invalidated the fundamental options selected for this plant and then used for the remainder of the 900 MW program.

The actual nuclear part itself suffered only a few failures of medium importance and the many changes that had to be made in the conventional equipment or equipment based on conventional designs were not of a radical nature.

Since the start of industrial operation, the record of time in operation of the two segments is good (78 and 82 percent), and higher than the value of 50 percent used in the PEON [Advisory Commission on the Production of Electricity of Nuclear Origin] studies. By way of comparison, the average time in actual operation of EDF's conventional thermal plants was 72 percent in 1977.

Figure 2 shows that the behavior of the two Fessenheim units since they supplied their first kWh to the network is fully satisfactory compared with other similar production facilities, such as the U.S. Beaver Valley plant, which was a point of reference for the nuclear part, and the Tihange plant, with similar secondary facilities to those at Fessenheim.

From the point of view of the performances expected, the behavior of the facility in its transitional phase seems very satisfactory; the regulations on "ilotage" [meaning unknown] and load variations (increase of 5 percent of nominal power per minute and spikes of ± 10 percent) are being respected; follow-up of load and adjustment by remote control are not authorized at the present time.

For the time being the behavior of the fuel is satisfactory; the total radioactivity of the water in the primary circuit (excluding tritium) is about 0.2 to 0.3 $Ci/m^3$.

The effects of the plant's operation on exposure of the personnel and the environment to radiation have been very slight.

The average annual dosages received by plant workers comes to 11 millirems for 1977 and 100 millirems for 1978; these figures may be compared with the value of 188 millirems for all of EDF's power plants in 1977. We must, however, say that these low values are not very significant, since they cover a period during which no refueling was done.

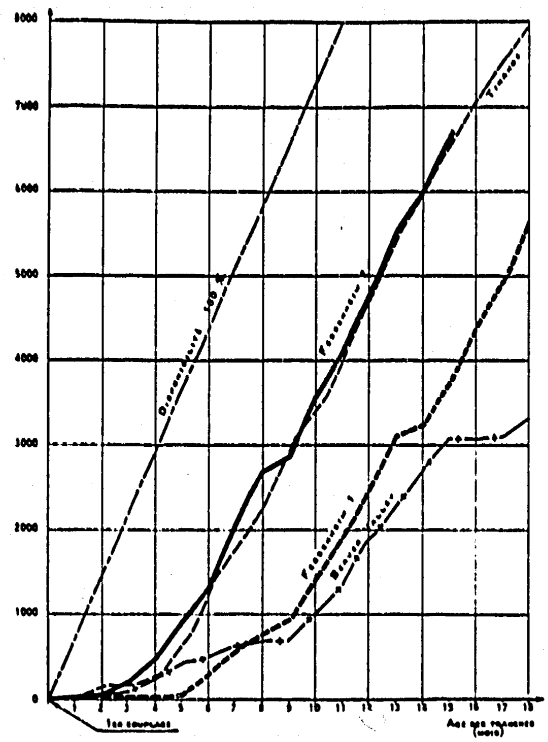



Figure 2: Behavior of Fessenheim in relation to Beaver Valley and Tihange.

Key:

1. Start of Fessenheim and several 900 MW PWR Westinghouse Units
2. Hours Equivalent to Full Power
3. 100 Percent Operation
4. First On-Line
5. Age of segments (in months)

Despite a larger production of effluents than expected, the radioactivity caused by wastes released in the water and air in 1978 reached the following levels in relation to the authorized values:

a. About 10 percent for liquid effluents (excluding tritium);

b. Less than 45 percent for tritium;

c. Less than 5 percent for gaseous wastes.

Consequences for the population with the highest theoretical exposure, based on very pessimistic assumptions, for 1977 gave an amount of irradiation equivalent to about 0.02 millirem for the entire organism; this is nearly 10,000 times less than the regulatory limit and than natural radioactivity.

VI What Was Learned From the Start and First Year of Industrial Operation

A. Conducting of the Starting Tests

There are obviously many reasons for the very satisfactory start of the power plant; in addition to the use of an already proven type of nuclear boiler, there are the good organization of the tests and a special adaptation of the resources used.

The organization of the tests, implemented gradually and becoming fully operational a year before the connection, was maintained until the start of industrial service of the two segments. The teams included personnel either from EDF's Equipment and Thermal Production Region or from the contractors, with the overall coordination in the hands of EDF. A very close cooperation between all the parties involved, primarily in matters affecting safety, greatly facilitated the progress of the various phases.

During this entire period, tests were carried out according to test procedures (about a thousand) drawn up in advance; their very extensive preparation (45,000 pages of documentation per segment) represented a major amount of work. For the tests and their followup EDF sent a special team which at peak came to nearly 30 people (engineers and technicians); personnel sent by the builder of the nuclear boiler amounted to a maximum force of 24 people.

Other positive factors were:

a. The rapid availability of the test results and their critical examination;

b. The very extensive followup of modifications made in circuits and equipment during the starting procedure;

c. Highly effective communications between researchers and people at the site.

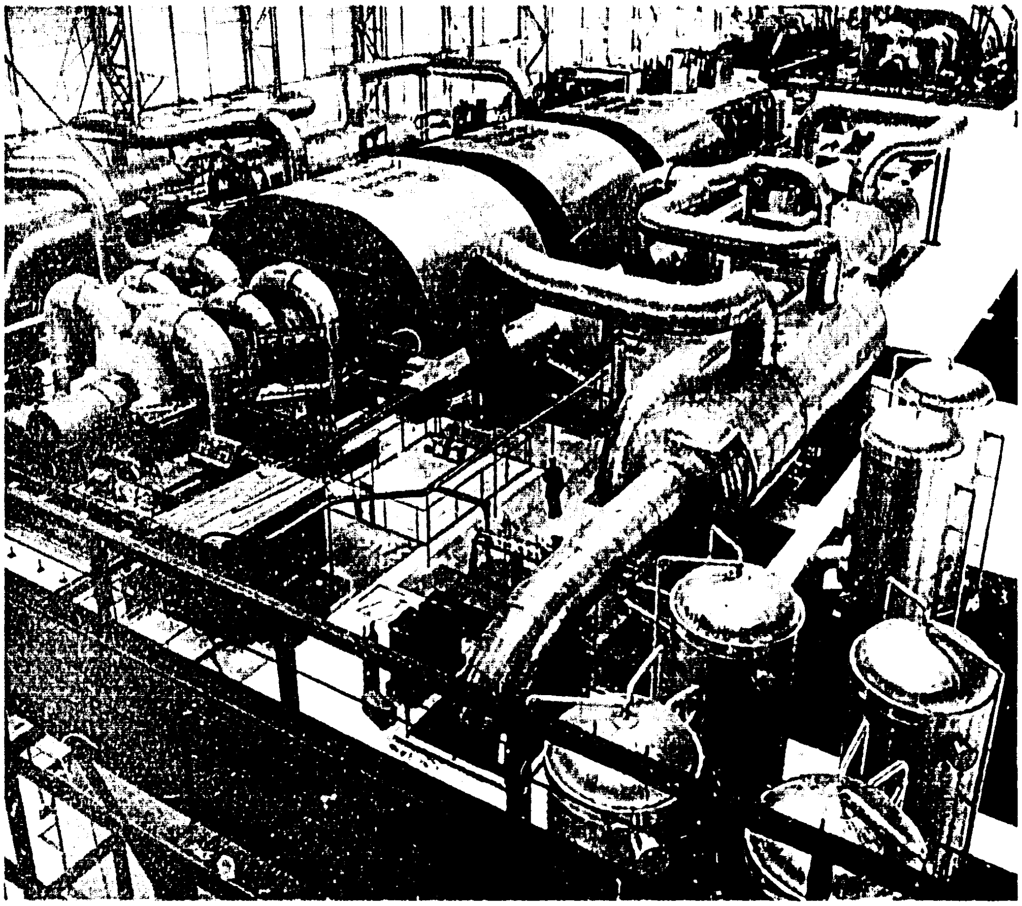
However, some changes should be made, as they caused too burdensome a workload, or significant delays: the effluent treatment system and the condition of the plumbing fall into this category.

Since the start of the rise in power, the somewhat larger than expected production of effluents and the high levels of radioactivity in the primary circuit at shutdown have caused large amounts of radioactivity in the liquid effluents, although the levels are still acceptable. The higher than expected production has still not been explained, for, on one hand, there are no means of identifying sources in the relatively complex collection circuits, and also because problems have arisen in reusing water from the primary circuit because of the length of time spent on improving the effluent treatment system (mainly evaporators and equipment for placing effluents in containers). The radioactivity could not be quickly eliminated as the flow passing over the demineralizers of the chemical and volume control circuit was generally too low. This radioactivity did cause some radiation protection problems.

Concerning the plumbing, the many (already listed) defects which caused loss of operating time and doses of radiation for the personnel during repairs should be reduced by decreasing the number and types of equipment, a better adaptation of the equipment to its function, precautions taken in installation, elimination of all unnecessary clamps, an appropriate selection of leakproof jointings, checking of clamps and the quality of connections.

B Organization of Operations

Since the start of testing, the plant's operating personnel have operated the equipment (from a centralized command room). This gave them additional training, and at the same time it tested the operating instructions (there are about 200 instructions contained in 2,000 pages).



Machine room -- 900 MW Turbo-Alternators.

Monitoring of the nuclear boiler is done exclusively from the command room with the exception of an inspection round in the reactor building during hot shutdowns or at least once a month.

Furthermore, the definitive safety report which was examined and approved before the authorization for industrial operation requires, throughout the entire duration of the plant's operation, that:

a. Numerous periodic tests of equipment or circuits be made while in use, in order to monitor and maintain the facility's degree of safety;

b. All procedures done by an operator be defined and controled in order to obtain the highest possible quality.

In this way the starting period was used to implement and validate the procedures used in these periodic tests. There are a great many procedures (about 500 for one segment, covering 5,000 pages of documentation), and their execution entails a great amount of work. Few problems have arisen with these test procedures.

To respond to the demand for quality in all the operations done, an ad hoc group was set up when the facility started to operate. This system, which is part of the existing hierarchical organization structure, has a double aspect:

a. A technical aspect related to the nature of the activities (operation, maintenance, training), which is described in written procedures (see above for information on operating instructions or periodic test procedures) listing for each of them the objectives, the methods and resources to be used, and the checkouts to be made.

b. A management aspect related to all of the steps taken to guarantee that the technical activities are carried out properly, using the structure and regulations of a quality control organization. This is based on a few simple principles: the definition of activities and equipment involved; these activities are to be entrusted only to skilled workers; to think before acting; and to report (systematization of written procedures -- nearly 2,000 maintenance procedures are described); to keep documents up to date and conserve them, to systematically verify the results of each activity (technical quality control done by the plant's operational services, and management control done by an independent section).

This organization was set up gradually over a period of about 1 year, and did cause some difficulties.

The start of operations also provided information on a number of important factors in personnel management. These concerned essentially:

a. Workers in each specialty, particularly operating personnel, those handling control-command equipment, and chemonuclear controls. The experience gained with the first refueling in 1979 is needed for more information for maintenance personnel.

b. Methods and resources used for personnel training, improvement, and replacement.

c. Steps to guarantee their protection from radiation during interventions.

We should also mention the experience gained in relations with outside organizations (government and public) in a relatively new field such as nuclear PWR for most of the parties involved:

a. Safety (SCSIN, IPSN /Nuclear Protection and Safety Institute/, the Standing Group;

b. Monitoring of equipment under pressure (Division of Mines, SIIM /Interdepartmental Services of Industry and Mines/, BCCN /Nuclear Construction Control Office/);

c. SCPRI, which deals with protecting the population from radiation;

d. Protection against sabotage (prefecture offices);

e. Information (Control Commission, press, public).

Maintaining these relations required a great deal of work which should yield good results with the future power plants.

This brief overview leads us to the conclusion that, despite the few delays which occurred during the rise in power, the first year of Fessenheim's on-line industrial operation has been very satisfactory, promising, and full of a great amount of information for the future.

The great majority of the incidents were related to the prototype nature of some equipment, and none of these incidents was of a nature to invalidate the options of the project and of the future 900 MW plants. In particular, there were no significant incidents affecting the nuclear part itself.

In the many areas of organization involved in the start and operation of a plant -- tests, operation, maintenance, personnel, relations with government agencies and the public -- for which the Fessenheim power plant was in many respects the first proving ground, the work done has been considerable and the experience gained will be very valuable for the rest of the nuclear program.

We will of course have to wait for confirmation of the present quality and performances: an incident causing a shutdown lasting several months is still possible in a "first of a series" facility like Fessenheim. And the first shutdown for refueling scheduled for 1979 will yield a wealth of information.

Still, Fessenheim now appears, after Tihange, to be an industrial success auguring well for the future.

Annexes

Technical Characteristics of the Fessenheim Power Plant

General specifications

Guaranteed nominal ratings

| | |
|---|---|
| Thermal power of boiler | 2,660 MW |
| Steam flow at turbine intake | 5,155 t/h |
| Steam pressure at turbine intake | 51.1 bars abs. |
| Condenser pressure | 48.5 mbars abs. |
| Gross electric power | 920 MW |

Nuclear boiler

| | |
|---|---|
| Number of primary circuits | 3 |
| Steam generators model | 51A |
| Primary pumps model | 93D |
| Fuel assembly type | 17 x 17 |
| Total thermal power | 2,660 MW |
| Thermal power created in the core | 2,652 MW |

| | |
|---|---|
| Nominal characteristics of feedwater | |
| Absolute pressure | 56.67 bars |
| Temperature | 216.8°C |
| | |
| Nominal characteristics of steam in insulation valves of enclosure outlet | |
| Total flow | 5,155 t/h |
| Absolute pressure | 52.57 bars (CV carbonized tubes) |
| Temperature | 267°C |
| Humidity | 0.25% |
| | |
| Acceptable load variations in normal operation between 15% and 100% of nominal power | |
| Levels | 10% of nominal power |
| Continuing variations | 5% of nominal power/minute |

Reactor and Fuel

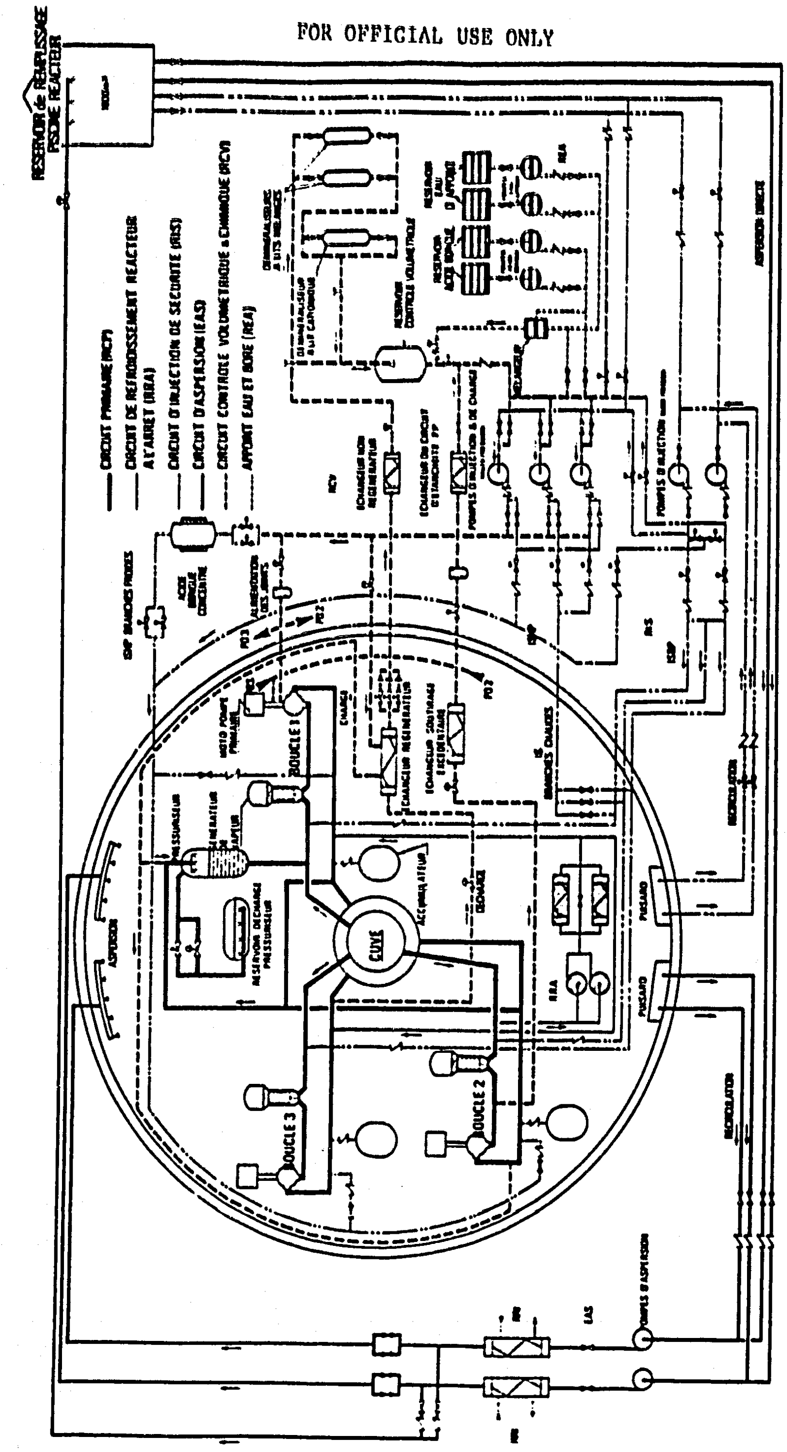
1) Thermohydraulic characteristics

| | | |
|---|---|---|
| Nominal pressure of primary circuit | | 155 bars abs. |
| Flow per circuit loop | | 20,100 $m^3/h$ |
| Actual mass flow of core | | 43,610 t/h |
| Average line power | | 170 W/cm |
| Maximum line power in normal operation | | 454 W/cm |
| Temperature of primary fluid at 100% of nominal power | tank intake | 284°C |
| | tank outlet | 322°C |

2) Mechanical characteristics

| | |
|---|---|
| Type of fuel | 17 x 17 |
| Number of assemblies | 157 |
| Number of pencils per assembly | 264 |
| Spacing of pencils (cm) | 1.26 |
| Overall size (cm) | 405.80 |
| Weight of $UO_2$ (daN) | 513.5 |
| Number of grids per assembly | 8 |
| | |
| Pencil | |
| Number | 41,448 |
| External diameter (cm) | 0.950 |
| Diameter clearance (cm) (regions 1, 2, 3) | 0.017 |

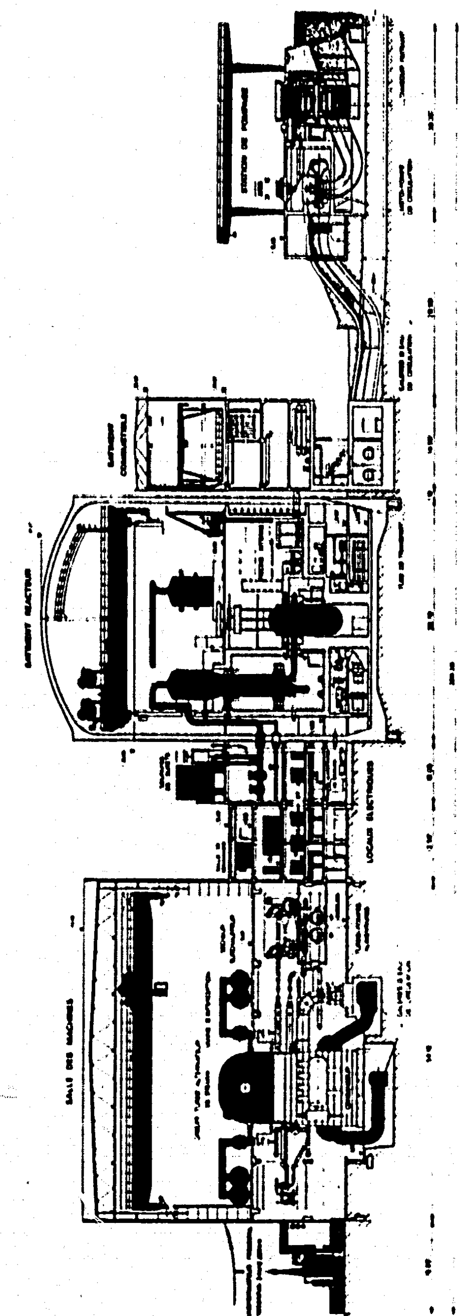
| | | |
|---|---|---|
| Shield thickness (cm) | | 0.057 |
| Shield material | | zircaloy 4 |
| Length (m) | | about 3.8 |
| Pellet | | |
| Material | | $UO_2$ |
| Density (% of theretical density) | | 95 |
| Diamter (cm) (regions 1, 2, 3) | | 0.819 |
| Width (cm) | | 1.35 |
| Cluster of absorbent pencils | | |
| Absorbent material, long pencils and short pencils | | Ag-In-Cd |
| Number of absorbent pencils per cluster | | 24 |
| Number of long clusters | | 48 |
| Number of short clusters | | 5 |
| Internal equipment | | |
| Core envelope | | |
| Internal/external diameter (cm) | | 340/350 |
| Thermal shield | | |
| Internal/external diameter (cm) | | 362/376 |
| Turbo-alternator group -- turbine | | |
| Thermal power | MW (th) | 2660 |
| Steam flow at turbine intake | t/h | 5156 |
| Steam pressure at turbine intake | bars abs. | 51.1 |
| Steam humidity at turbine intake | % | 0.40 |
| Steam flow at intake of low pressure case | t/h | 3525.5 |
| Pressure at intake of low pressure case | bars abs. | 10.31 |
| Exhaust steam flow | t/h | 2851.5 |
| Exhaust steam pressure | bars abs. | 0.037 |
| Coupling power | MW | 933.61 |
| Specific consumption at coupling | kj/kWh | 10,260 |
| Alternator | | |
| Apparent power (Pa) | MWA | 1026 |
| Active power | MW | 923.56 |
| Total specific consumption | kj/kWh | 10,372 |
| Power factor | | 0.9 |
| Voltage between terminals (Un) | kV | 24 |
| Intensity | kA | 24.6 |



Schematic of Reactor's Primary and Auxiliary Circuits

Key:

1. Tests
2. Spray pumps
3. Spray
4. Pressurizer
5. Steam generator
6. Loop 3
7. Discharge tank pressurizer
8. Primary motor pump
9. Loop 1
10. Tank
11. Accumulator
12. Loop 2
13. Discharge
14. Charge
15. Exchanger regenerator
16. Surplus bleeding exchanger
17. Hot branches
18. Drain pits
19. Recirculation
20. Cold branches
21. Boric acid concentrate
22. Connection feed
23. Primary circuit (RCP)
24. Reactor cooling circuit at shutdown (RRA)
25. Safety injection circuit (RIS)
26. Spray circuit (EAS)
27. Volume and chemical control circuit (RCV)
28. Water and boron addition (REA)
29. Tank for Filling Reactor Pool
30. Demineralizers using mixed beds
31. Cation bed demineralizer
32. Non-regenerating exchanger
33. Exchanger for seal circuit
34. Volume control storage tank
35. Boric acid tank
36. Water tanks
37. Injection and charge tanks (high pressure)
38. Mixer
39. Boric acid pumps
40. Water pumps
41. Injection pumps (low pressure)
42. Direct spray



Transversal View of the Power Plant

Key:

1. Machine room
2. Main transformer
3. 970 MW turbo-alternator group
4. Intercept valve
5. Dryer-superheater
6. Condenser
7. Feed turbopumps
8. Circulating water tunnels
9. Command room
10. Safety valves
11. Electric rooms
12. Emergency feed pumps
13. Reactor building
14. Internal pool
15. Transfer tube
16. Fuel building
17. Pumping station
18. Circulating water tunnels
19. Circulation motor pump
20. Filtration drum

## Development Prospects

Paris REVUE GENERALE NUCLEAIRE in French Dec 78 pp 471-473

/Article by Michel Durr, head of the 1300 MW level in EDF's Equipment Division/

/Text/ The author describes the present status of development of the first 1300 MW level power plants. He then discusses the work being done at Paluel, Flamanville, St Alban/St Maurice-L'Exil, and Cattenom.

I Paluel

The Paluel site on the English Channel near Saint Valery en Caux is scheduled to have four 1300 MW segments with open cooling using sea water. The public utility decree was issued on 23 July 1975 and the preparatory site work began in June of that year.

Paluel 1

a. Begun in 1976
b. Order to start work on components of the nuclear boiler: 1 January 1976

c. Order to build boiler and start of first concrete work at the site: 1 July 1977
d. Start of industrial service scheduled for February 1983.

Paluel 2

a. Begun in 1977
b. Order to build boiler: 1 November 1977
c. Start of industrial service scheduled for May 1983.

Paluel 3

a. Begun in 1978
b. Order to build boiler: 1 August 1978
c. Start of industrial service scheduled for June 1984.

Paluel 4

Segment planned, to begin in 1980, and be operating at the end of 1985.

A. Present Status of Studies

Most of the studies have been done and we will mention only the main points:

a. Control: studies concerning control are being done to permit followup of load and adjustment by remote control.

b. Steam generator: the decision not to use the preheating system and the steam generator with 11/16" tube caused a 6-month slippage in the studies, which delayed the start of industrial service of Paluel 1, which was shifted from August 1982 to February 1983. To combat the denting phenomenon[1], that is, the corrosion of cross-plates of the bundle of tubes, which leads to a reduction in size of the tubes and causes stress on the plates, stainless steel plates with quadrifoliate holes will be used.

c. Controbloc: EDF has decided to use, starting with Paluel, the "Controbloc" system of control-command

---

1. See the article by Mr Coudray, "Recent Technological Developments in Pressurized Water Reactors," REVUE GENERALE NUCLEAIRE no 4, 1977.

featuring static relay developed by CGEE /General Electrical Equipment Company/-Alsthom. This system was tested at the Saint Ouen plant for command of six burners. A report on it was made to the SFEN /expansion unknown/ on 24 November 1978.

d. Reactor control - SPIN. Framatome is studying a microprocessor relay system for reactor control. The decision to use or not to use this system, presented to the SFEN on 23 November 1978, will be made in 1979. The method now in use in reactors of the 900 MW program has a conventional electromagnetic relay.

Table I: 1300 Mw Segments -- Development Plans

| Year | Segment | Order to Build Nuclear Boiler | Start of Industrial Service |
|---|---|---|---|
| 1976 | Paluel 1 | 1 Jan 76 * | 1 Feb 83 |
| 1977 | Paluel 2 | 1 Nov 77 * | 1 May 83 |
| 1978 | Paluel 3 | 1 Aug 78 * | 1 Jun 84 |
| Expected in 1979 | Saint Alban 1 | 1 May 79 | 1 Nov 84 |
| | Flamanville 1 | 1 Jul 79 | 1 Jan 85 |
| | Cattenom 1 | 1 Oct 79 | 1 Jul 85 |
| Expected in 1980 | Paluel 4 | 1 Mar 80 | 1 Sep 85 |
| | Saint Alban 2 | 1 Apr 80 | 1 Oct 85 |
| | Flamanville 2 | 1 Jun 80 | 1 Dec 85 |
| | Cattenom 2 | 1 Dec 80 | 1 Jun 86 |

* Order actually given.

B Status of Work at the Beginning of November 1978

1. Earthwork at the site

Despite the disruptions caused by strikes in the spring, the major part of the earthwork has been done (8 million cubic meters, including 4 million cubic meters of chalk). There were some problems caused by the depositing of this soil, for compacting had to be done with a sufficiently dry material. To obtain a suitable hygrometry reading, ashes from coal-burning plants had to be added at times. This ensured the later stability of the deposits. It was also almost impossible to work with this soil during rainy periods, because of the mud formed. There are still about 1 million cubic meters to be moved in 1979 (secondary excavation for segment 4, platforms for no 4, pumping station for 3 and 4).

2. Protective dam and sea water feed channel

This work was made more difficult by the presence of a very hard crystallized limestone bar which has changed the original work schedule, and will require removal by the use of explosives. The total volume to be moved is about 300,000 $m^3$.

3. Pumping station

Work on this station is done behind a sheet piling. The earthwork is done for segments 1 and 2. The concrete for the circulating pumps for pumping station no 1 is being poured. The apron for the pumping station for no 2 has been poured.

4. Main civil engineering work

a. Segment 1

The apron of the reactor building is done. The first raising of the dual-structure containment enclosure is being done now. The pillars of the machine rooms are done and the group table is being built.

b. Segment 2

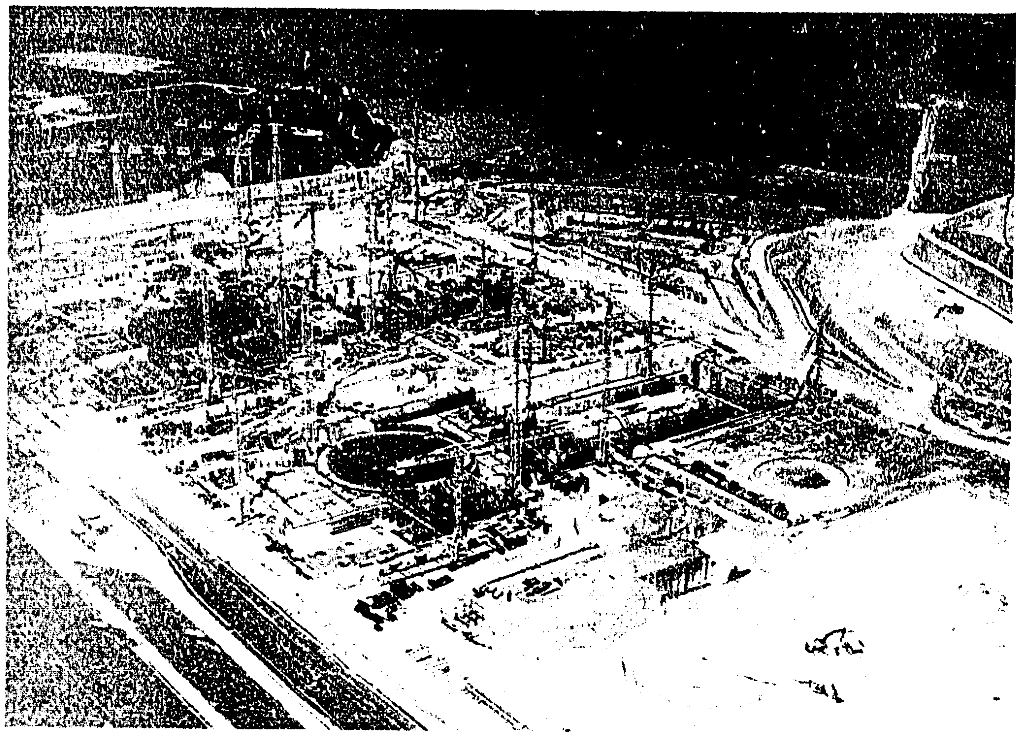
The apron of the reactor building is being built.

c. Segment 3

The iron work for the apron has begun. The main problems have been caused by strikes which have paralyzed the site for a total of 14 weeks since the work started.

II Flamanville

A public investigation of the Flamanville site, on the west coast of the Cotentin area between Carteret and La Hague, began on 5 November 1976 and the decree of public utility was issued on 22 December 1977. The site is partially embedded in a granite cliff and partially (for the machine room) built on fill soil. It is to have four 1300 MW segments using open cooling by sea water.



Flamanville Site: General View (August 1978).

The decision to authorize a platform built over the sea was signed on 5 January 1978. Several suits were filed about this, and the Caen administrative court on 28 April 1978 issued a ruling halting work under the building permit obtained at the same time as the DUP /Public Utility Decree/. One of the reasons was the absence of an environmental impact study, although this was not required at the time the building permit was requested. After completing the appropriate report, EDF filed a new request for a building permit, without waiting for the administrative court to rule on the first permit. The second building permit was issued on 20 July 1978.

Removal of rocks from the cliff and construction of the platform were disrupted by these legal problems. Work considered to be related to the building permit was blocked until 20 July. This affected mainly the crushing station.

More than a third of the originally scheduled earthwork has already been done (of an original total of 5,000,000 m3). However, the poor quality of the soil is going to increase the volume to be moved (change in grade of the slopes). In fact, the granite is much more crumbly and broken than the drillings had shown.

Civil engineering work on the first segment should be ready to start in the summer of 1979.

III Saint Alban/Saint Maurice-l'Exil

The public investigation of the Saint Alban/Saint Maurice-l'Exil site near Peage-de-Roussillon began on 2 May 1977 and the DUP decree was obtained on 29 September 1978. Four 1300 MW segments are planned at this site. The first two units will have open cooling on the Rhone, and the second pair will use atmospheric cooling.

The preliminary work of site clearing and fill of the platform is being done now. Civil engineering work should start during the first quarter of 1979.

IV Cattenom

The public investigation of the Cattenom site near Thionville began on 9 May 1977 and the DUP was signed on 11 October 1978 for two 1300 MW segments using atmospheric cooling. A reservoir in the immediate vicinity of the site will keep too hot water from being dumped in the Moselle river in the summer. Another reservoir in the Vosges will restore water evaporated in the cooling facility to the Moselle. The earthwork is being done and the civil engineering work is scheduled to begin in the autumn of 1979.

Editors' Note: In this article, the author discusses only the 1300 MW plants which had obtained a public utility decree as of 15 November 1978. But there are other 1300 MW power plants now in the planning stages.

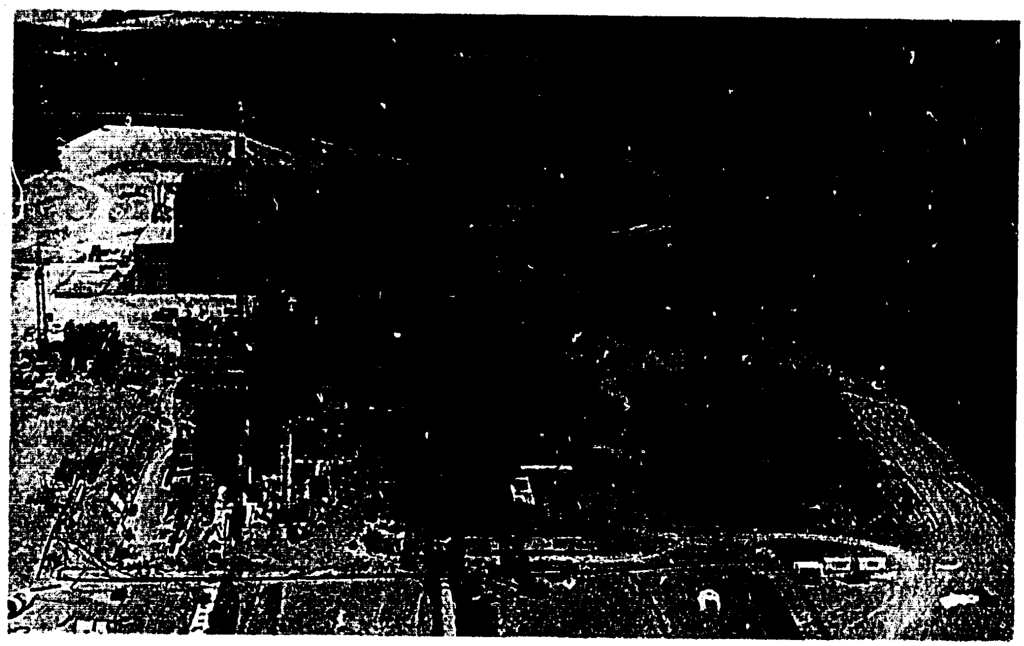
## Creys-Malville Power Plant

Paris REVUE GENERALE NUCLEAIRE in French Dec 78 pp 474-475

/Text/ This report discusses the construction work which began at the Creys-Malville site at the beginning of 1977, after completion of the preparatory work. Some information is given on the civil engineering work, the construction of the nuclear boiler, and other electro-mechanical equipment.

For over 20 years France has been devoting sustained efforts to the development of sodium-cooled breeder reactors.

After Rapsodie (thermal power of 28 then 40 MW), which was put in service by the CEA /Atomic Energy Commission/ in 1967, then Phenix (250 MWe) put in service in 1973, the Creys-Malville power plant (1200 MWe) is now being built on the banks of the Rhone in the department of Isere, near the department of Ain, 60 kilometers above Lyon.



The Super-Phenix Power Plant at Creys-Malville: General View in June 1978.

The prime contractor for the project is the NERSA firm /European Fast Neutron Power Plant/, of which EDF holds 51 percent of the stock, ENEL /National Electric Power Agency/ 33 percent, and SBK 16 percent.[1]

The nuclear boiler, which by itself accounts for 2/3 of the total investment, is being developed by the Novatome-NIRA /Italian Nuclear Company for Advanced Reactors/ group.

The civil engineering for the entire plant is being done by the group consisting of Fougerolle, Condotte d'Acqua, and Fred Holzmann.

The turbo-alternators are being supplied by the Italian firm Ansaldo.

All the other work and equipment, including the Novatome-NIRA subcontracting, has been awarded to firms of the nationalities represented in NERSA.

Construction of the plant began at the site in early 1977, after completion of the preparatory work, which consisted mainly of building a horizontal platform of approximately 15 hectares at the edge of the Rhone. This work was facilitated by the exceptional quality of the terrain found at all depths at the Creys-Malville site.

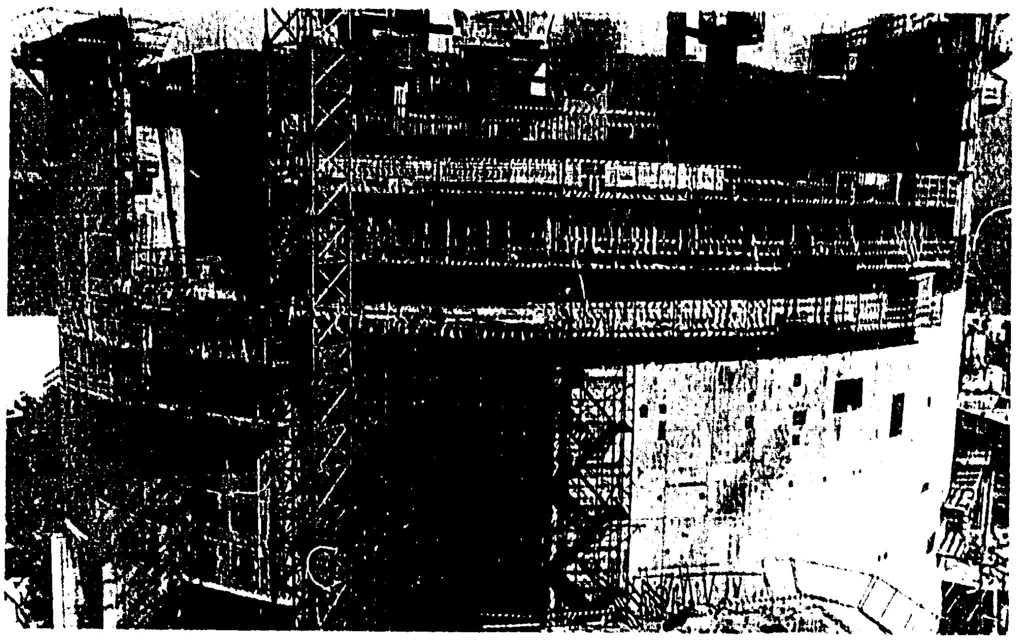
Civil Engineering

First of all, the civil engineering includes the reactor building whose external structure, a concrete cylinder 65 meters in diameter and 80 meters in height, has already reached 50 meters in height. Then there are the steam generator buildings, the machine room (the concrete for the group tables has been poured), the miscellaneous auxiliary buildings, and the hydraulic system for water intake and outlet.

All this work is well advanced and on the whole, nearly half of the total amount of concrete planned had been poured at the end of 1978.

---

1. ENEL is the Italian equivalent of EDF, and SBK is a German firm established by RWE, the largest electricity producer in the Federal Republic of Germany, along with Belgian and Dutch producers.



View of the Reactor Building at the end of September 1978.

The Nuclear Boiler

Work done in factories

Deliveries of all the major components are well advanced and the machining is done in the factory. Therefore, it would be a waste of time to list them all and give their state of completion.

Moreover, unlike the PWR power plants, the reactor's main components are not completed in the factory but, because of their size, they are assembled in a shop built at the site; for that reason we will discuss the activities of this shop.

•

Work done at the site

The first thing that attracts the attention of a visitor to the Creys-Malville site is the immense shop (1 hectare on the ground and 38 meters high), which was built by the Novatome-NIRA group for assembling and machining reactor parts which could not be transported by road, because of their size. These are parts such as: tanks, closing slab, protective dome, etc. Conditions here are quite similar to those found in a factory. Novatome-NIRA's subcontractors share the work areas, where preformed sheets sent from the factories are beginning to arrive.

Some large circular parts are machined in this shop on a special machine tool which has a circular disc 13 meters in diameter.

Among the components for which parts are being made in the shop at the site are:

a. The main tank and the safety tank;

b. The slab: assembly of parts of the external rim has begun;

c. Baffles and various parts of the reactor.

Installation in the reactor building has obviously not begun yet, but the piling that will be used for moving in large reactor components, such as the tanks, is already in place.

Other Electro-Mechanical Equipment

The firms of various nationalities from which NERSA has ordered the supply and installation of components of the plant, excluding the boiler, have begun machining of this equipment in their plants.

This equipment includes:

a. Turbo-alternator groups for which all the shafts are now being made;

b. Condensers; drilling of their tubular plates has started.



APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100040062-8

At the end of 1978 there were about 1,000 workers at the Creys-Malville site, most of whom were employed by the group of firms doing the civil engineering.

Personnel from the assembly and installation firms will now start to increase rapidly and the maximum workforce at the site, about 1,500 people, should be reached at the end of 1979.

To improve housing and living conditions for the workers, NERSA has developed or will develop -- under the "major construction site" regulations -- housing facilities for single persons with 200 beds, and later 300, parking facilities for campers, a restaurant, and social services operated jointly by the various firms involved in this project.

7679
CSO: 3100

END