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Maintenance of major Edf components

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ABSTRACT : The evolution of French Nuclear Power plants (54 reactors operating in 1994) has led Edf, like other operators, to carry out major maintenance operations.

In particular, at the main primary coolant circuit, the behavior of components made from Inconel 600 has led to:

1. The replacement of steam generators on three units: Dampierre 1 in 1994, Bugey 5 in 1993 and Gravelines1 in 1994. Ten further operations are proposed over the next ten years. Dampierre 3 and Saint-Laurent b1 are scheduled for 1995.

2. The replacement of five vessel heads and if necessary 15 to 20 others over the next ten years.

Standardization of French power plants has led Edf to develop a so-called series strategy for these maintenance operations involving substantial investments in process tooling. This strategy has enabled Edf to obtain excellent results very quickly.

The most recent application of this approach was the SG replacement operation at Gravelines which took 43 days from the end of unloading until hydraulic testing with an overall dosimetry of 1.4 HSv, thereby placing French industry at the forefront for this type of operation.

CHARACTERISTICS OF FRENCH POWER PLANTS

The French NPP series consists of 54 PWR and 2 fast reactors.

The 54 PWR reactors are classified into 34 900 MW reactors and 20 1300 MW reactors.

The 900 MW reactors break down into six of the CPO type and 28 of the CP type, and the 1300 MW reactors break down into two groups: 8 P4 reactors and 12 P'4 reactors.

Four N4 model reactors which are currently being constructed have to be added to this list.

The French Nuclear Power Plant program has been built around the series concept, i.e. quasi-uniform series of reactor, each series integrating experience feedback from the previous series.

The first reactors now provide 18 years' operating experience (CPO series at Fessenheim and Bugey).

MAINTENANCE STRATEGY

Due to the nature of its power plants, Edf has had to adopt a series approach to maintenance identical to the approach used for its construction program, and in particular must take account of all the initiating events which may have serious consequences on unit availability.

French PWR reactors are a development of the Westinghouse models and as such, the choice of Inconel 600 as the basic material for certain components in the primary coolant circuit was not questioned in 1974 (SG tube bundles, vessel head penetrations).

From an early date (after 5 to 6 years operation, at the start of 1980), Edf had to face stress corrosion problems in the Inconel used in the steam generators and, more recently (1992), the same problems on vessel head penetrations.

Edf first tried to understand this phenomenon through a series of very detailed and advanced studies and to implement preventive and curative repair procedures (such as shot peening), and to examine the possibility of replacing components.

In the case of the steam generators, a first group of units (10 to 12 reactors) proved not to be capable of reaching the reactor service life due to the high rate of tubes affected.

Edf therefore decided to envisage their replacement by taking into account all the parameters which would enable the works to be optimized.

In the case of the vessel heads, technical and economic analyses undertaken on the affected units led to similar conclusions, i.e. the replacement of the vessel head in a strategy of optimized siting of the works.

GENERAL PRINCIPLES ADOPTED FOR MAJOR MAINTENANCE OPERATIONS

The method adopted by Edf has been directly inspired by the approach used for new constructions, i.e. the notion of series.

Once the decision had been taken, EDF's aim was to minimize the impact of these operations during an elementary unit shutdown, but also as part of overall unit management and associated industrial means.

As to the replacement components, series production runs started on completion of the technical studies resulted in the best possible product, optimized the workload of the fabrication plants involved and obtained the best prices.

Maintenance operations involve substantial scheduling work, costs, rigorous delivery dates and technical difficulties, and as such a very detailed methodology was applied to the preparatory phase.

On completion of the generic feasibility studies which enabled the overall process to be defined, special tooling dedicated to these specific tasks had to be designed and produced.

These tools, such as welding, cutting and decontamination equipment, were developed and tested in actual working conditions. A training center was specially developed to reproduce the almost exact working conditions which would be encountered.

In parallel with these developments, precise studies of the works procedures were gathered together in work files which detailed all the operations both from the technical, Alara, scheduling, security and safety standpoints.

The operators who had to work in the plants underwent special training and qualification during long weeks prior to the actual operations.

All of these preparatory stages involved costly and time-consuming investments but were justified by the generic aspect of problems and the need to avoid improvisation during the works.

For example, preparation of the steam generator replacement operations was spread over four years (time needed to manufacture the equipment) and cost FF200 M.

That of the vessel head replacement was spread over two years and cost FF60 M.

On completion of the first operation, which was considered a prototype, experience feedback was integrated in the procedures in order to optimize future operations.

INDUSTRIAL ORGANIZATION ADOPTED

Edf is the architect - engineer for these operations.

Framatome is responsible for supplying the replacement components and for a large part of the works on site (for example the works on the primary and secondary coolant circuits and SG handling during generator replacement operations).

Other contractors, according to their field of competence, become involved in this type of operation (decontamination, handling, insulation, piping, shielding, civil works, ancillary systems, scaffolding, etc.).

Standard contracts are negotiated with these contractors in order to achieve the best possible productivity and economic optimization.

Specific project teams have been appointed within Edf for this type of operation and work on several sites.

VESSEL HEAD REPLACEMENT

The first operation took place on the Bugey 5 unit in 1993.

The new head had changed penetrations from Inconel 600 to Inconel 690, and benefited from the manufacturing improvements developed on the N4 series.

The operation involved a standard exchange of the CRDM on two sites at once: dismantling of the mechanisms on the former head, checking and grinding down and reinstallation on the new head.

The vessel head was removed from the reactor building.

It was subsequently temporarily stored on site and then transported to a national long-term storage center.

Operations on the PWR 1300 series required additional infrastructures for vessel head handling.

The units at Bugey 2, Bugey 3, Bugey 4, Bugey 5, Gravelines 4 and Blayais 1 underwent these operations in 1992, 1993 and 1994. A rhythm of six operations is proposed each year excluding 1995, i.e. four 900 PWRs and two 1300 PWRs.

The 54 vessel heads installed in France will thus be changed over the next ten years.

The operation required about 22 days.

The cost of an operation on a plant in the 900 PWR series is estimated at 50 MFF.

REPLACEMENT OF STEAM GENERATORS

The operation to replace the steam generators is positioned between a unit shutdown and a new construction operation.

300,000 hours are worked in all (Edf + contractors).

Two years' preparation are required for each unit including nine months on site.

The operation requires two to three months intensive and continuous work in the reactor building.

The reactor is shut down around 15 weeks and the dosimetry is 1.4 H.Sv.

The main principles adopted for the series of operations are as follows:

1. the change involves a single assembly (apart from CPO in the case of Bugey 5)
2. mechanical cutting of primary coolant piping
3. decontamination of primary coolant elbows
4. so-called 2-cut method without replacing elbows
5. specific metrology, association with topometry
6. narrow beveled welding of primary coolant pipes
7. storing of steam generators on site in a specially erected building
8. intensive training of staff.

The first operation took place in 1990 on the Dampierre site. It validated the principles adopted and resulted in the series strategy that was implemented in 1993 (Bugey 5) and 1994 (Gravelines 1). The results of the so-called series methodology were particularly positive for steam generator replacement operations.

Plant	Operation	Durations (Days)	Dosimetry (Man-Sv)
Dampierre 1	1990	84	2.13
Bugey 5	1993	86	1.52
Gravelines 1	1994	43	1.4

The work durations correspond to all the operations from the end of unloading until hydraulic testing.

The Bugey operation had to be a two-assembly version due to the handling problems encountered. Saint-laurent 1, Dampierre 3 are scheduled for 1995 and Tricastin 2 for 1996.

CONCLUSION

The specific nature of the French NPP has led EDF to develop a special approach to heavy maintenance operations.

A methodology based on the notion of plant series, and involving almost identical procedures from one plant to another in the same series, required substantial investments in the preparatory phases (manpower and equipment) and the setting up of close collaboration with the different subcontractors.

However, feedback from the first vessel head and SG replacement operations has shown that this strategy is particularly suited to the French context and enables EDF to limit the economic impact of these operations, which are proving to be unavoidable at some stage during the service life of plants.

