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SUMMARY

The national development efforts for future PWR's in France and Germany are now being combined into the development of the "European Pressurized Water Reactor" (EPR) with the support of the French and German utilities, who intend to use this design by the end of this decade.

The EPR is an evolutionary and innovative development based on the latest units in operation or under construction in France and Germany.

The basic design target is to further reduce the probability of accidents in particular severe accidents leading to large releases of radioactivity.

The defence-in-depth has been enlarged, providing mitigative features for low pressure core melt scenarios.

The paper presents the organization and the time schedule foreseen for the future development work, summarizes the safety objectives and describes the technical solutions selected so far in cooperation between Nuclear Power International, Siemens and Framatome on the supplier side and EDF and member of German utilities as the first potential users of the new design.



RECENT DEVELOPMENTS IN ENGINEERED OR INHERENT SAFETY

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1. Introduction

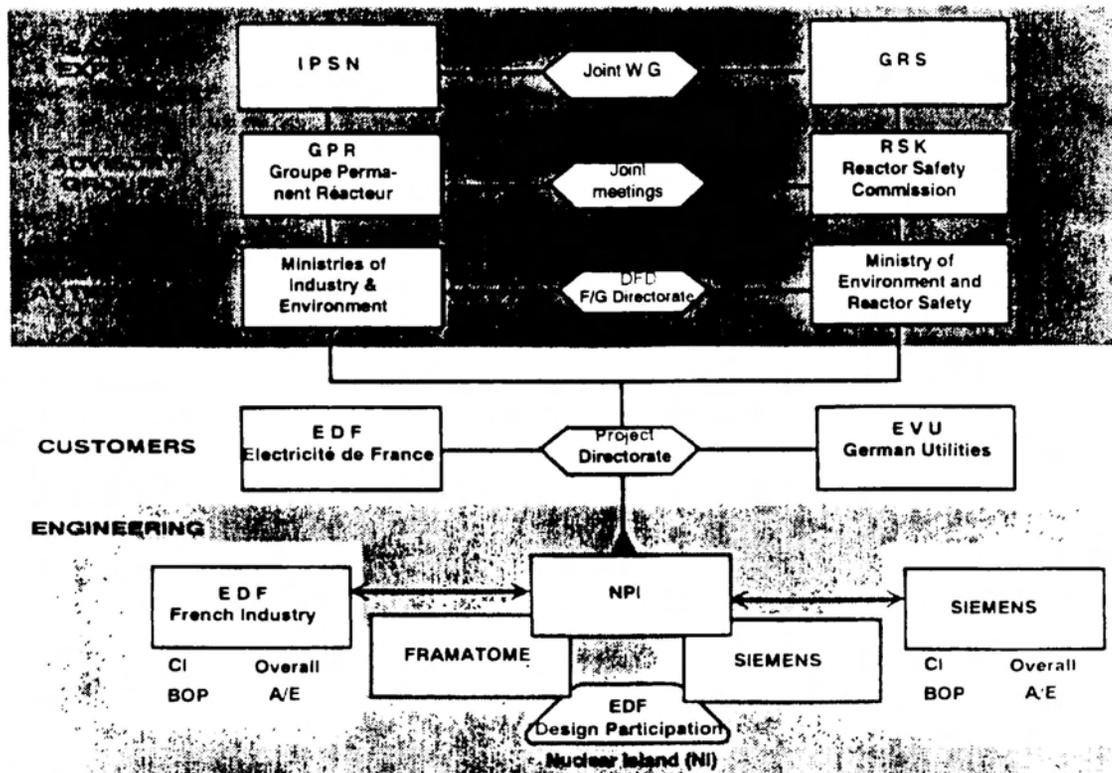
In discussions with Electricité de France (EDF) and a number of German utilities, the conceptual safety features of the future common "European Pressurized Water Reactor (EPR)" have been agreed upon to a large extent.

The paper describes the organization and the time schedule of this project, gives a short summary of the safety objectives and the technical solutions selected so far to fulfill these objectives.

2. Organization and Time Schedule for the Development of the EPR

Significant progress has been made towards a real industrial development approach in which all institutions normally involved in the Nuclear-Island in France and Germany participate.

On the customer side, EDF and a number of German utilities agreed to merge their former development programs and to fully support the EPR development with the aim to implement the EPR simultaneously in France and Germany. The organization of the project is shown in Figure 1.



EPR - Overall Organization

Fig. 1

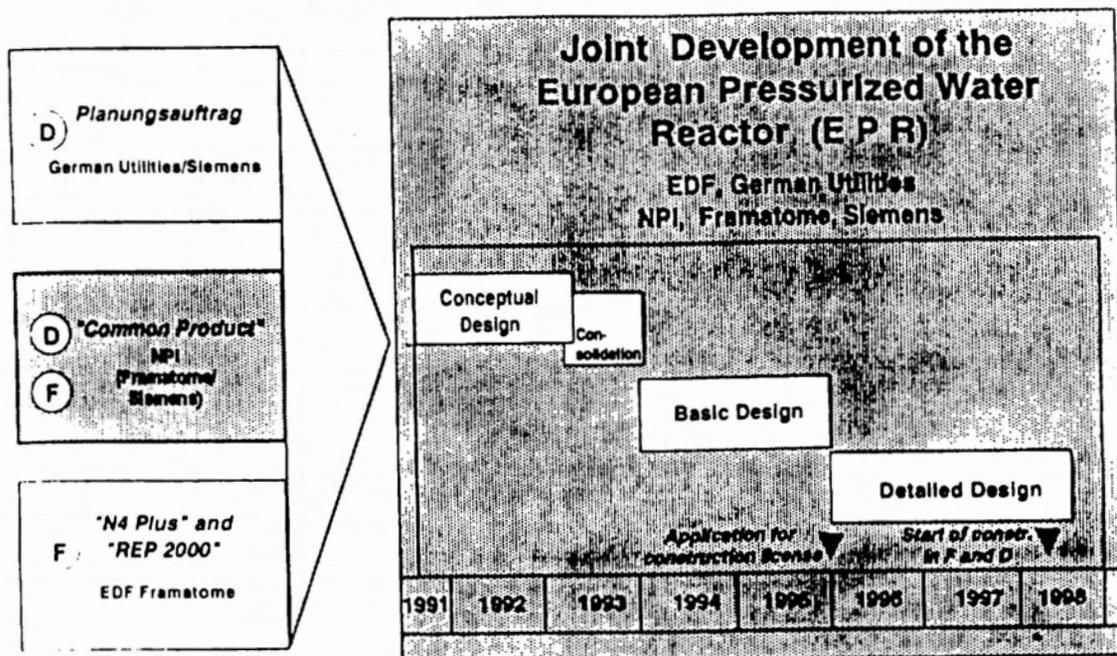
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EDF and the German utilities are steering the customer interests through a joint Project-Directorate. On the safety-authorities side joint-working groups and meetings between Safety Experts, Advisory Groups and Safety Authorities have been established in order to harmonize the requirements of the licencing authorities in France and Germany for future Pressurized Water Reactors. The Engineering effort for the Nuclear Island is performed jointly by NPI, Siemens and Framatome with a participation of EDF, whereas the Conventional Islands will be designed by EDF and the France industry for projects in France and by Siemens for projects in Germany.

The time schedule for the development is shown in Figure 2. We are presently in a consolidation phase, during which the results of the Conceptual Design is discussed with the utilities. The basis of this discussion is a comprehensive "Conceptual Safety Features Review File", which at the time of INC 93 will be in the hands of the safety authorities in France and Germany.

In the beginning of 1994, we will start the Basic-Design phase, lasting about two years and comprising essentially all documentation necessary to apply for a construction licence and a budgetary estimate. The first construction of an EPR could then take place in 1998.

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Harmonization of French and German Development Lines

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Fig. 2 DS29044F

3. Safety Objectives

In order to fully benefit from the experience with more than 100 000 MW electrical capacity in operation, under construction or on order by Framatome and Siemens, the EPR will be an evolutionary development on the basis of the German Konvoi and the French N4 design and hence rely on the well proven defence-in-depth concept which is currently the basis for PWR safety concepts in France, Germany and most of the developed countries.

Probabilistic risk assessments (PRAs) will be used to demonstrate that the various families of accidents or transients to be taken into account have a balanced contribution to the overall probability of severe accident scenarios. PRAs will also be used to prove a sufficiently low probability for severe accidents leading to large radioactivity releases.

On the basis of a set of agreed upon assumptions and data for initiator frequencies, equipment failure data and in particular common and human failure mode models, we have adopted a design target, that no family of events should lead to a core melt frequency higher than 10^{-7} /year, which is consistent with an overall core melt frequency of 10^{-6} /year for internal events.

Despite these low probabilities for severe accidents we will implement as an innovative feature mitigative measures to cope with severe accident-scenarios.

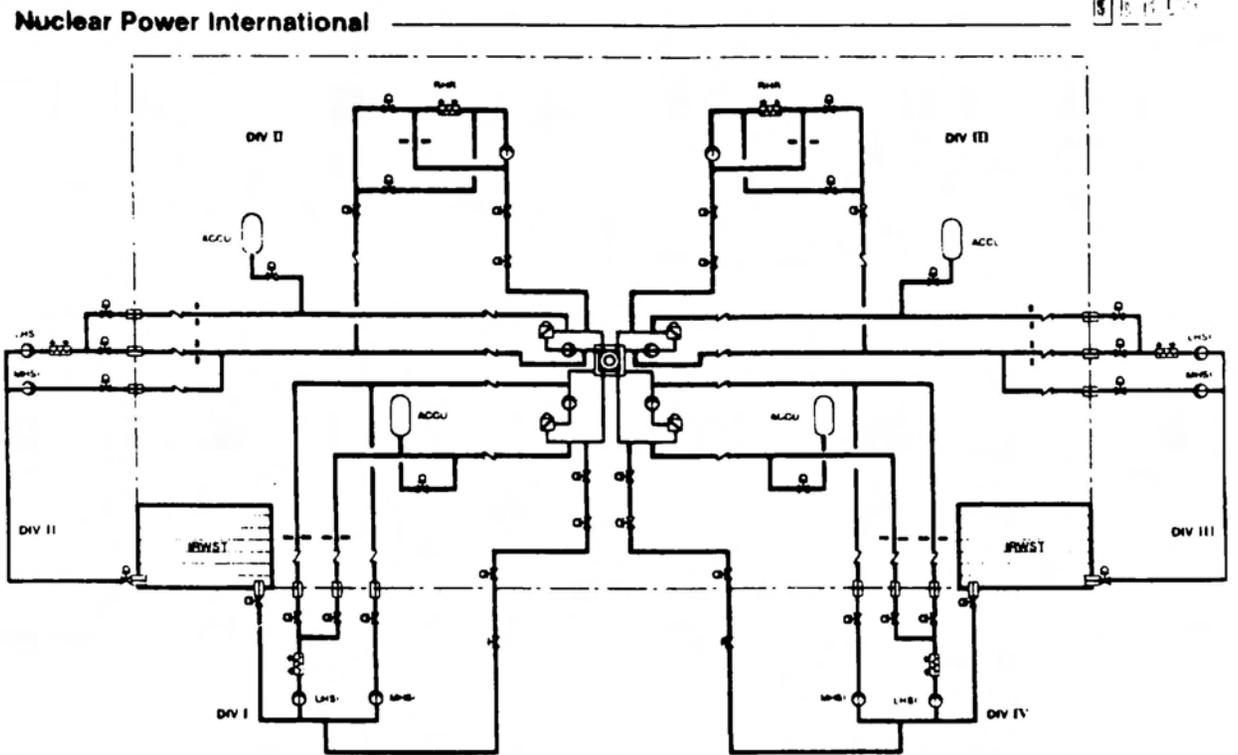
The overall strategy is defined in such a way, that the probability of high pressure core melt scenarios, potentially challenging the containment, shall be reduced to a level below 10^{-7} /year by providing a highly reliable secondary heat removal and a safety grade primary bleed-system.

The low pressure core melt scenarios shall however be taken into account in the design. Proposals for technical solutions to this end are given in chapter 4.3 of this paper. The target is that the radioactive releases for these low pressure core melt scenarios will be sufficiently low to restrict emergency response actions like evacuation or relocation to very small and defined exclusion areas.

4. Technical Solutions

4.1 Primary Side Safety Systems

The safety systems on the primary side are shown in figure 3. The safety systems are arranged in four totally separated divisions.



Primary side safety systems

Fig. 3

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Each division includes a low head and a medium head safety injection system. Both systems take suction from an incontainment water storage tank (IRWST), which is also used for core cooling in the short term following a core melt accident.

The low pressure injection system is connected to both the hot and the cold leg of a loop and allows together with the accumulator connected to the hot leg a fast quenching and reflooding of the core. Heat-exchangers in the low pressure injection system allow a heat removal after loss of coolant accidents.

The medium head safety injection system is connected to the cold leg of the loop. Its delivery head is limited to a value below the set point of the relief and safety valves on the secondary side. In case of a steam generator tube failure, the affected steam generator will be isolated after the initial transient thereby limiting the releases due to such events to a negligible level.

A two train residual heat removal system located inside the containment will be provided. Two of the low pressure safety injection systems can be used as a back-up for these residual heat removal systems.

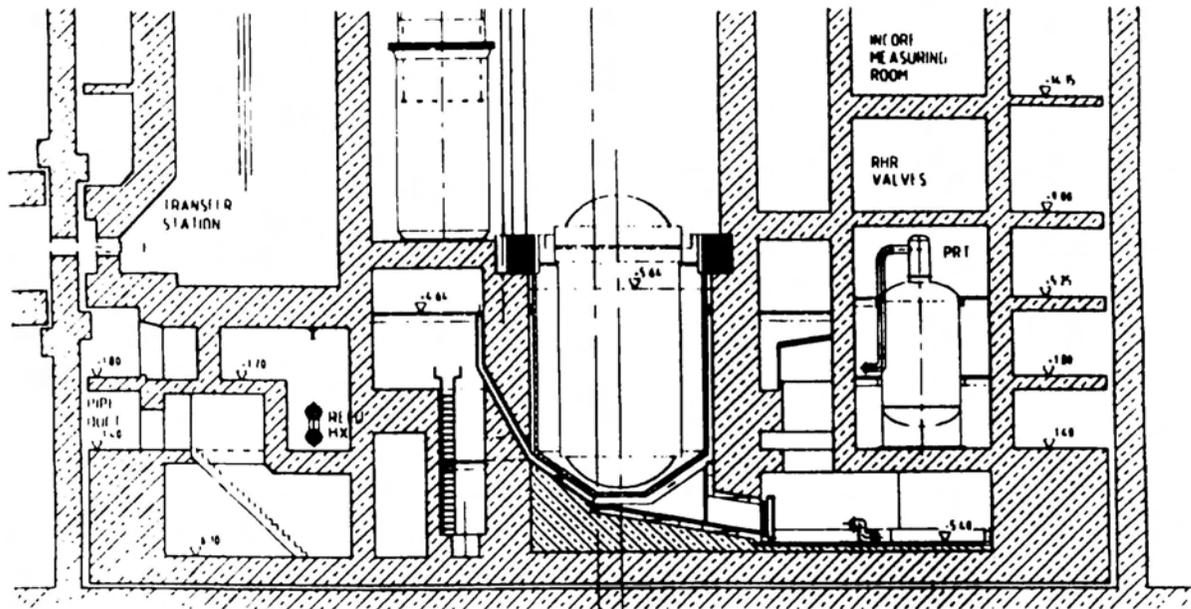
4.2 Secondary Side Safety System

A highly reliable secondary side feed water supply, consisting of main feed water pumps, a start-up and shut down pump and 4 redundant emergency feed water pumps will be provided. The emergency feed water pumps will be electrically driven, a diverse source of energy supply is under consideration.

4.3 Mitigative Features for Low Pressure Core Melt Scenarios

As mentioned above, low pressure core melt scenarios shall be taken into account in the design.

Figure 4 shows in principle the measures foreseen to provide a spreading area of about 150 m² for the corium with a protective layer to prevent core-concrete interactions. The corium can be cooled in the short term by using the water from the IRWST. For the long-term heat removal from the containment, we are planning to install a dedicated spray system which will however be needed only about 1 day after the accident.



**EPR : Core melt stabilization
Spreading Concept (Section A - A)**

Fig. 4

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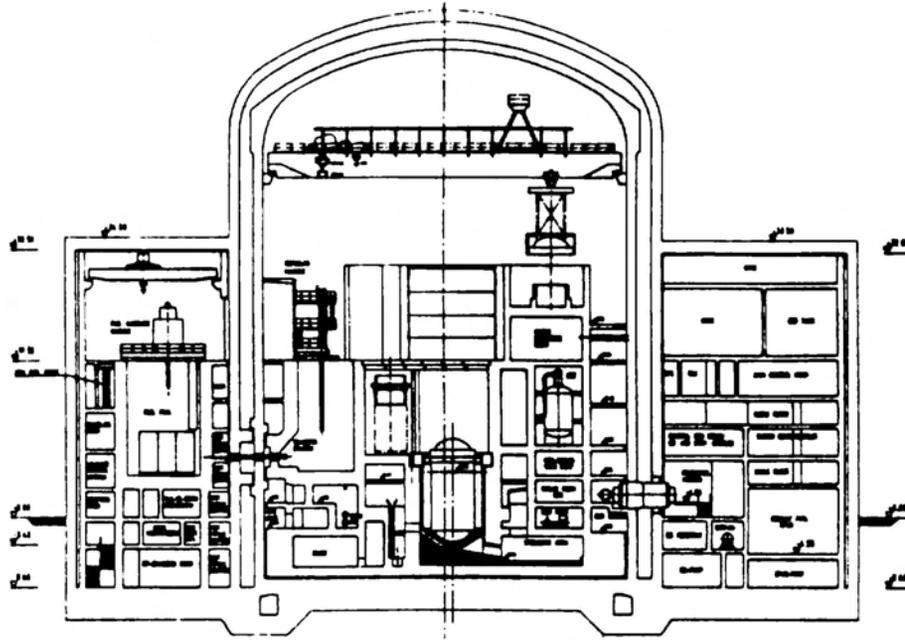
A combination of hydrogen recombinors and possibly igniters will ensure that only deflagration of hydrogen has to be taken into account in the containment design. These measures together should guarantee the long-term retention capacity of the containment and render a containment-venting system unnecessary.

4.4 Containment and Lay-out of the Nuclear Island

The containment represents the third and ultimate barrier in the defense-in-depth concept and is therefore of particular importance for mitigation of accident consequences including severe accidents. The selected containment consists of a prestressed concrete cylinder. It is surrounded by a second reinforced concrete cylinder. Leakages from the primary containment can such be collected in the annulus between the two cylinders and filtered before release to the stack.

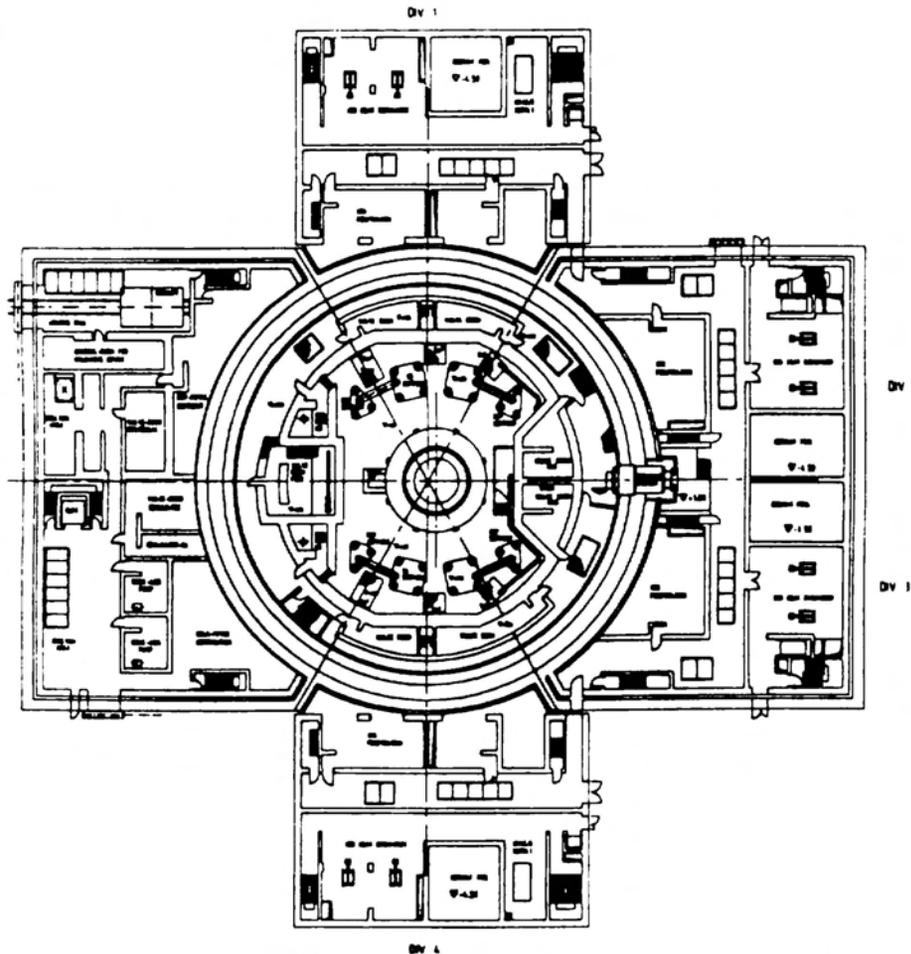
A cross-section of the reactor building is shown in Figure 5, the respective arrangement of the 4 divisions and the fuel storage around the containment is shown in Figure 6. The arrangement of the buildings housing the safety systems is foreseen in

such a way, that they are located on a single raft for seismic design reasons and that at least two divisions can be protected against external events such as aircraft-crash and explosions waves.



EPR
Building Arrangement
Section A-A

Fig. 5



EPR
Building Arrangement

Fig.6

4.5 Instrumentation and Control

As foreseen for the fluid systems and their electrical supply system, the Instrumentation and Control will be organized into four divisions ensuring a high signal reliability.

All actions necessary within the first 30 minutes will be performed automatically. A fully digitalized I + C technology together with a modern cockpit-type control room will provide optimal information to the operating personnel.

Conclusion

By involving the utilities and the safety authorities, the development effort for the EPR has become a real industrial project. It combines the vast experience of the French and German utilities and Nuclear Power Plant suppliers with innovative features for future PWR's and will thus be a perfectly suitable solution for nuclear projects towards the end of this decade and beyond.