E U R O S A F E

Towards Convergence of Technical Nuclear Safety Practices in Europe

DIFFERENT SAFETY OPTIONS PROPOSED FOR THE EPR AND FOR THE VVER/V-392

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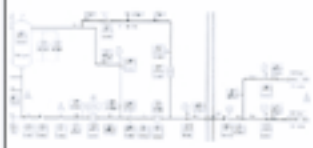
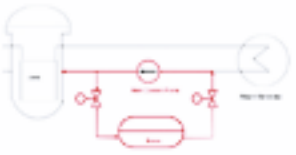
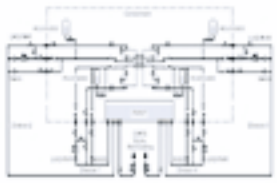
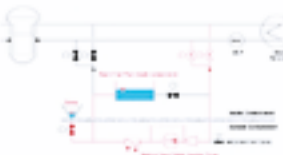
In 1989 the French and German governments requested all concerned organisations to create a safety referential for future reactors. In the same year a Franco German working group has been created for the evaluating of the common design started at that time by Framatome and Siemens.
A Franco German Committee of the regulators (DGSN and BMU) has been established at the end of 1990.
In 1993 the common approach has been created for the safety evaluation of the future reactors. On this base 50 common (IPSN/GRS) reports were prepared and discussed during the 20 meetings of the Franco German advisory committees.
A summary of all recommendations drawn during these meetings has been adopted in March 2000. This concluded the conceptual phase of the EPR design. During this period, the EPR concept on the systems has been significantly optimised due to the recommendations given by GRS and IRSN (e.g. ultimate heat sink, containment heat removal, fuel pool cooling).
A new phase is started in 2001 with the goal to elaborate in 2003 the preliminary safety analysis report of the EPR.
In order to enrich the background of their experts in the licensing process of the EPR, GRS and IRSN have carried out a review of some other PWRs that belong to the same vintage as EPR.
This poster gives a general overview of different options proposed by EPR and AES 92 (new VVER 1000) designers in order to cope with the same safety concerns.

EPR	AES-92/V-392
Basic principles for safety	***Basic principles for safety***
• **Functional and/or structural diversity** for systems. • **Active and passive (accumulators) systems.** • In general, 4 trains **architecture** for active safety systems including the support systems. The concept allows to assume 2 trains lost due to **Single Failure Criteria and maintenance.** So maintenance of safety systems (including their support systems) is allowed during plant operation without time restriction. • Use of **active safety system for normal operation** functions is not allowed in principle except the Reactor Heat Removal System (combined with SIS). • Full pressure double containment provided with an Hydrogen Removal System, an Annulus Ventilation and filtering System and a core melt catcher. Containment spray is not needed for Design Basis Accidents. • Confinement integrity ensured without venting, even in case of Severe Accidents. However Containment Spray System (CHRS) is used to cope with some Beyond Design Basis sequences.	• **Functional and/or structural diversity** for systems. • **Active and passive** (2 stages of accumulators, heat removal, quick boron injection, annulus passive filtration) systems. • 4x100 % **architecture** for active safety systems and 2x200 % for support and protection safety systems (in case of accident the support systems automatically switch on the 4x100 % configuration). The concept is **Single Failure** tolerant. Maintenance of support and protection safety systems is limited during plant operation as follows: 14 days for one train and 3 days for 2 trains together. Configuration of passive systems: 4x33 %, 4x25 %, 1x100 %, depending on function. • Use of **active safety system for normal operation** and for safety functions: e.g. the Spent Fuel Cooling System is used as an Emergency Core Cooling System in case of accident. Steam Generator blow-down system becomes secondary side heat removal system in case of an accident. This allows to avoid unidentifiable defects. • Full pressure double containment provided with an Hydrogen Suppression System, a Containment air discharge and purification (filter) system, an Annulus passive and active Ventilation and filtering System and a core melt catcher.

> Safety Function: Achieving and Maintaining of Subcriticality

EPR	AES-92/V-392
Systems needed to transfer the reactor into subcritical state	Systems needed to transferthe reactor into subcritical state
• **SCRAM** (gravity driven rods as in already existing plants) • **Extra Borating System** (2 trains with injection capacities of 10*Vh and the transporting time of 5-6 minutes). Start-up is automatic for ATWS and manual for all other cases.  **to make a simplified scheme**	• **SCRAM** (gravity driven rods, number significantly increased compared to V-320 in order to keep subcriticality down to 100 °C without boron injection). • **Quick Boron Supply System.** Passive system of 4 loops bypassing the main coolant pumps. Each loop consists of a hydro-accumulator containing concentrated boron acid solution, and of pipelines with quick-acting valves hanked up by batteries which open automatically in case of ATWS. Transporting time is 10-15 seconds. Boron acid is transported by the Main Coolant Pump flow. 

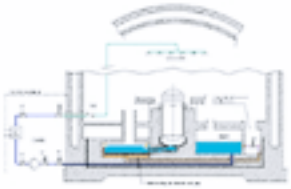
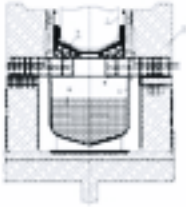
> Safety Function: Cooling of the Fuel

EPR	AES-92/V-392
Systems needed for the core cooling (Safety injection)	Systems needed for the core cooling (Safety injection)
• 4 trains of Medium Head Safety Injection (80 bar) • 4 trains of Low Head Safety Injection (20 bar) • 4 Accumulators (45 bar ; 4x12 m³) 	• 4 trains of Medium Head Safety Injection (max head 80 bar) equipped with ejectors allowing to provide the lower outlet pressure (below 20 bar).  • 4 Accumulators (60 bars/50 m³) • 8 Accumulators (15 bars/120 m³) 

EPR	AES-92
Systems needed for the core cooling (**Heat removal** via secondary side)	Systems needed for the core cooling (**Heat removal** via secondary side)
• **Normal Feed-Water and Start Up and Shutdown Systems.** • **Active Emergency feed water system in conjunction with Steam Generator Safety Valves and Steam Relief Valves to Atmosphere.**  • **Primary Feed & Bleed. Pressurizer Safety Valves.**	• **Normal Feed-Water and Start Up and Shutdown Systems.** • **Active Emergency SG cool-down system (closed loop, using the classified part of the SG blowdown system).** Normal operation Emergency operation  • **Passive residual Heat Removal System.** Air-cooled heat exchanger is installed outside of the containment. The heat exchanger is connected to the SG secondary side in a way that the steam from the SG is condensed in the heat exchanger and returns into the SG (natural circulation). 

> Safety Function: Retention of Activity

EPR	AES-92
Systems needed for the confinement	Systems needed for the confinement
• Containment is designed for severe accident pressure (residual H2 deflagration, gradual pressure build-up). • Double containment equipment with a liner at least in specific areas. • No direct leak risk. • The residual heat is removed from the containment without release (device : in liquor form (more than 12h) CHRS can be used (see below). 	• Full pressure double containment equipped with hydrogen removal system, containment air discharge and purification (filter) system. • The Safety Injection System can be used as a containment spray system.  • Passive heat removal from the containment allowing to limit its pressurisation (see P-H/S diagram above).

EPR	AES-92
Provisions for severe accidents	Provisions for severe accidents
• Recombiner (in depth justification of the location, capacities, number ...in function of the selected envelop-scenarios). • Depressurisation of the primary circuit through "Dedicated" pressurizer-depressurization valve, in order to avoid high pressure core melt. • Corium catcher and cooling (CHRS). 	• Recombiner (in depth justification of the location, capacities, number ...in function of the selected envelop-scenarios). • Corium catcher 

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