THE BEHAVIOUR OF UNDERGROUND SITED REACTOR CONTAINMENT STRUCTURES UNDER EXTREME EXTERNAL AND INTERNAL LOAD CONDITIONS

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SUMMARY

A study has been carried out on underground siting of large nuclear power plants in which due to the soil conditions in Germany, the "cut- and cover" technique was emphasized. This paper deals only with the reactor building of a PWR. First, the underground structure with foundations either 30 or 55 m below the surface had to be designed to fulfil the standard safety requirements for nuclear power Plants, i.e. it must be able to withstand external loads from earthquakes, pressure waves and aircraft impact. The height of the coverage was determined by the last. Calculations showed that 6 to 8 m reduced the aircraft impact load including its time-dependency just to a value which demanded no additional reinforcements in the concrete structure. The other external loads have no further substantial influence on the design of the whole structure, which was determined by the deadweight of the coverage as well as by earth and groundwater pressure. Because of its low probability, it has not been necessary to take into account the failure of the spherical steel containment and no conditions of internal pressure have been considered for the reactor building itself. However the underground siting offers an inherent potential to withstand such loads without prestressing and an approach was made therefore to investigate this capacity.

A set of load conditions has been derived covering a spectrum of postulated internal reactor accidents. For example, in the case of failure of the primary circuit of the reactor combined with partial failure of the emergency cooling system and of the steel containment itself, the concrete structure must sustain a time-dependent inner pressure with a maximum of about 6 bar a transient temperature of the inner atmosphere between 140 °C and 90 °C. The overall stability of the structure was the main criterion for the dimensioning and not its gas tightness, because of the fission product retention capacity of the surrounding soil. Cracks across the whole section of the structure can generally only occur in regions with resultant tensile forces, i.e. the upper parts of the shell-like structures. In fact the reinforcement will allow only distributed, small cracks which will cause no mechanical damage to the water-insulation on the outside of the structure. In the case of a long-term inner pressure of more than approximately 3 bar a certain quantity of hot steam may penetrate through the walls of the reactor building. Then, the probability of cracks can be reduced to a level sufficiently low either by restricting the concrete tensile stresses by thicker concrete walls or by prestressing. Furthermore, the effect of a possible impact of the lid of the reactor pressure vessel on the top of the reactor building has been investigated.

To summarize, the study shows the effect of underground siting on the dimensioning of PWR-reactor buildings and their capacity to withstand extreme internal loads.