Safety of Fusion Power Reactor Concepts in the View of the German Nuclear Fission Regulation

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In the course of a review of the safety of fusion reactor concepts the transferability of the new German nuclear fission safety regulation (SiAnf) was analysed. The nuclear fission safety regulation SiAnf was developed with the German nuclear power plants (NPP) in mind. With regard to safety principles intended for fusion power plants (FPPs), the principle of the concept of defence in depth can – to some extend – also be applied to FPP. The safety requirements and safety concepts for FPP has been developed in parallel with their design in respect of the concept of defence-in-depth. The SiAnf is based on three fundamental safety functions: “confinement of the radioactive materials”, “cooling”, and “reactivity control”. Due to the differences in the physical nature of the fusion and fission reactions, the last fundamental safety function applies only to the ability to terminate the power production. The SiAnf are very specific with the type of barriers to confine the radioactive inventory in a NPP. Due to the differences in quality and quantity of the radioactive inventory in a FPP confinement strategy with different barriers has to be developed. In NPPs the decay heat from used fuel elements has to be removed by active systems to avoid eventual fuel damage. In FPPs the decay heat from activated structures of the in-vessel components (blanket, divertor, etc.) has to be removed by active and passive cooling methods, so the fundamental safety function “cooling” can be applied. If it can be proven, as preliminary studies have shown, that the heat can be removed passively, reduced requirements would apply for the detailed implementation. Like in a NPP in a FPP measures and installations are foreseen to limit the consequences of postulated initiating events to the radiological criteria of the applicable level of defence. Inherent physical principles, as well as passive and active safety systems are used for these measures and installations. Due to the current level of detail for the design of future FPP, the criteria for the measures and installations on the different levels of defence are not yet as detailed as for a fission power plant. The SiAnf requires the analyses of external hazards, e. g. earthquakes and flooding, or very rare human-induced hazards, e. g. the crash of a large air plane. These advanced requirements will also be applicable to future FPPs. Therefore, together with the development of more detailed plant concepts also events resulting from external hazards related to the natural environment and to human activities have to be taken into account.