Abstract

This thesis presents an extension of the Probabilistic Safety Assessment (PSA) oriented toward applicability in High Temperature Gas-cooled Reactors (HTGRs). The PSA methodology is a widely used approach for evaluating the safety and reliability of Nuclear Power Plants (NPPs). It plays a pivotal role in the licensing process by providing a quantitative evaluation of potential accident sequences and the associated risks which can be used to identify and prioritize potential scenarios, and to improve the reactor design. The objective of this research is to improve the standard PSA analysis by incorporating life-cycle simulations of systems reliability and availability, as an alternative to the conventional static Event Tree (ET) and Fault Tree (FT) calculations. The study focuses on addressing the limitations of the PSA methodology in the context of HTGR applications and adapting it to the unique operational conditions and safety features of HTGRs. To achieve these goals, the traditional PSA model is developed, encompassing ET and FT analyses for a representative initiating event in HTGRs, specifically focusing on the Loss of Forced Cooling accident(LOFC). Furthermore, the novel approach is proposed to replace the standard FTs with comprehensive life-cycle simulations, enabling a more accurate assessment of system reliability and availability within the PSA models. The proposed methodology is applied to the High-Temperature engineering Test Reactor (HTTR) as a reference HTGR, with a specific emphasis on the Depressurized Loss of Forced Coolant Accident (DLOFC) variant. By analyzing the frequency of LOFC and its associated risks, the proposed approach demonstrates its effectiveness in providing a comprehensive evaluation of potential accidents in HTGRs. Moreover, the improved PSA methodology proves to be adaptable and effective in assessing the risks associated with a range of potential accidents in HTGRs. The findings of this work indicated that the improved PSA methodology is a viii comprehensive and valuable tool for the design and safety evaluations of HTGRs. The new method reflects the unique characteristics and operational conditions of HTGRs, thus providing a more realistic assessment of potential risks and crucial insights for reliable and safe operation.