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P2.229 Methodology of probabilistic risk assessment for tokamak-type fusion reactors

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The world's largest tokamak fusion device-ITER is under construction in Cadarache, France, and first plasma will be officially identified in 2025. Building on the work of ITER, various countries are planning the steps needed for the fusion demonstration reactor (DEMO), and many conceptual designs for the fusion power plants (FPP) have been developed, such as PPCS of the European Union, ARIES of the United State and FDS of China. Importantly, the societal risk indicator of nuclear accidents has not been well understood and assessed for the tokamak-type FPP. Probabilistic risk assessment (PRA), which has long been applied in fission nuclear reactor development, would be a promising way for this object.
In this contribution, a typical deuteron-tritium tokamak FPP was selected for this study. Initiating events under the full power operation conditions were identified after elaborate analysis of mobilizable radioactive materials, energy sources and confinement barriers. Possible accidents evolutions for these initiating events were expanded by event tree method, and the accidents sequences were categorized by their environmental release routes. Representative initiating events and accidents sequences for all release routes were identified based on the possible consequences, and the frequencies of accident sequences due to each initiating event were thus calculated. Doses of representative accidents were assessed according to the average (best estimate) meteorology defined by DOE, and a complementary cumulative distribution function (CCDF)-based risk curve was obtained reflecting the societal risk, which describes the frequencies of exceeding given doses summed over the contributions to risk from the entire spectrum of accident sequences. It is illustrated that, for the tokamak-type FPP, PRA method could also be an effective risk assessment method, and provide insights and suggestions in its design and development.

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