High complexity in fusion reactor and harsh operating environment (such as high temperature, high radiation and high vacuum) demands tough reliability requirements for Structures, Systems and Components (SSCs) as well as nuclear materials. This requires that reliability of systems and components in the fusion reactor has been resolved for sustained energy conversion and transfer.

At present time, safety design approach and reliability performance index are far from systematic for fusion reactor design. The absence of probabilistic-safety-goal-based reliability index for SSCs has been resulting in low availability and considerably below fusion facility testing and engineering requirements. Effective solution for reliability challenge encountered during the engineering phase of the fusion energy requires initiatives in the following aspects: (1) determine probabilistic safety goals applicable to fusion reactor; (2) establish availability and reliability design targets for safety significant SSCs using PSA technique; (3) develop reliability database and necessary software tools to measure the performance indicator of SSCs against the established targets.

In the preparation of conducting reliability and probabilistic safety assessment for fusion reactor, some preliminary research work have been done, for example: a) Reliability Availability Maintainability Inspectability (RAMI) analysis of the dual-functional lithium-lead test blanket system (DFLL-TBS) was performed in the current conceptual design phase; b) A determination method of k factor was used to adjust pipe failure rate of Helium Cooled Ceramic Breeder (HCCB) TBS tritium extraction system (TES), which could be also applied to failure rates adjustment of other fusion reactor components; c) Probabilistic safety assessment of the dual-cooled waste transmutation blanket for the FDS-I and preliminary safety analysis and failure modes and effects analysis (FMEA) for the Chinese dual-functional lithium-lead test blanket module (DFLL-TBM) were also introduced; d) A method was proposed for selecting bounding events for ITER DFLL-TBM safety analysis.

This paper describes the research activities related to the determination of safety goals for fusion reactor and the process of allocating them to reliability design targets for SSCs. Reveals the importance of systematic establishing reliability performance index and provides guidance for various reliability research activities to be conducted during design, construction, commissioning and operation of fusion reactor.

Keywords: Fusion, Probabilistic Safety Goals, Reliability Performance Index