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# Demo Design Criteria for In-Vessel Components – Strategic Vision and Overarching Considerations

In-Vessel components in fusion nuclear systems have to withstand a very harsh combination of loads and environmental conditions which leads to designs that are significantly more complex and distinct from those of fission components. The ability to accurately predict component performance in in-vessel conditions, factoring in suitable design margins against critical failure mechanisms, is an overarching concern from a safety as well as investment protection perspective for the realisation of DEMO fusion power plant.

This requires a critical evaluation of the typical failure mechanisms that are usually considered for design assessment of existing nuclear components. This evaluation shall consider both their relative individual significance from a limit state design perspective as well as their applicability for the selected in-vessel components'materials and the fusion in-vessel operating conditions. Furthermore, the possibility of ductile and brittle failure mechanisms being intertwined over the design life of a fusion component requires clear understanding and evaluation of potential synergistic effects to optimise the component life and prevent premature component failures in service.

One possible approach to achieve this objective is the development of specialized material models that can simulate material responses in the plastic regime even beyond maximum tensile strength (utilizing post-necking residual deformation capacity), along with advanced predictive visualization of component behaviour under various loading conditions. These advanced, non-linear FE methods provide scope for recalibration of the stringent limits imposed against damage modes within the conventional nuclear design codes and standards. They provide opportunities to expand the design space with a clear basis for defining pragmatic allowable damage margins for different failure mechanisms, thereby addressing plant-level requirements for a maintenance-free operational period as mandated by the DEMO project. Simultaneously, they ensure overall alignment with the broader IAEA definitions and anticipated regulatory expectations.

To that end, this presentation will highlight the driving objectives, structure and status of the DEMO Design Criteria for In-Vessel Components (DDC-IC), currently under development in EUROfusion. Their goal is to complement the existing codes and standards and to provide a higher level of granularity in the structural integrity design qualification approaches specific for fusion in-vessel components. The presentation will also highlight the salient aspects associated with the design principles and associated design rules that are under consideration within the DDC-IC. This will include the arguments serving to investigate the core assumptions and theoretical basis associated with selected design rules within existing codes and standards as well as the avenues being explored to address the "gaps".

The short-term objective of this initiative is to establish the DDC-IC as a viable single point of entry for DEMO in-vessel component design rules to ensure consistency and coherence in DEMO concept design assessment activities. It is also anticipated that over the longer-term, the DDC-IC will be systematically developed as a fully integrated and harmonized guideline for structural integrity qualification of standardised fusion in-vessel component designs.

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