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FUNCTIONAL SAFETY ASSESSMENT OF A LIQUID METAL DIVERTOR FOR THE EUROPEAN DEMO TOKAMAK

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A reliable strategy for the heat exhaust problem for fusion reactors is among the milestones indicated in EUROfusion (2018). In a fusion reactor, the divertor targets are subject to extremely large heat and particle fluxes. For fusion to be economically feasible, these conditions must be withstood without damage for long time. The "baseline" strategy will be employed for the ITER experiment (which is being built in France) and is based on actively cooled tungsten *monoblocks*. It is unclear whether this strategy will extrapolate to a future fusion reactor (such as the EU-DEMO, whose pre-conceptual design is ongoing within the EUROfusion consortium). For this reason, alternative solutions are under study, which will eventually be tested in a dedicated experiment in Italy, namely the Divertor Tokamak Test (DTT). One possibility is to employ *liquid metal divertors (LMDs)*, for which the plasma-facing surface is inherently self-healing and immune to thermo-mechanical stresses.

Within the framework of the pre-conceptual design of an LMD for the EU-DEMO, *safety issues* need to be considered at an early stage. In this work we present a preliminary but systematic safety analysis for this system, by means of the *Functional Failure Mode and Effect Analysis (FFMEA)*. The FFMEA allows to identify possible accident initiators for systems undergoing pre-conceptual design, when more specific safety evaluations (e.g. at the component level) are not possible, US Nuclear Regulatory Commission (2009). This is done by postulating the loss of a system function rather than a specific component failure, thus compensating for the lack of detailed design information. For each function, the potential causes of its loss, a plausible evolution and preventive and mitigative measures are investigated, possibly specifying the need for further information. The initiating events are grouped according to consequences and the plant response. For each group, the Postulated Initiating Event (PIE) is chosen. The PIEs list drives and limits the set of accidental scenarios which will undergo deterministic analysis in a successive phase of the work, in order to evaluate the capacity of the system to withstand/mitigate its consequences. This will assess whether safety limits are respected or whether additional safety provisions are required. From the PIEs list, the design basis accident (DBA) and beyond design basis accident (BDBA) will eventually be selected.

Keywords: Nuclear Fusion, Liquid Metal Divertor, Heat Exhaust, Safety assessment, FFMEA, Initiating event

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