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In-box LOCA accident analysis for the European DEMO water-cooled reactor

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Transient analysis in a water-cooled fusion DEMO reactor have been performed to support the WCLL (Water-Cooled Lithium Lead) breeding blanket design. In this framework, the Design Basis Accident analysis of an in-box LOCA has been carried out.

The WCLL breeding blanket concept relies on Lithium Lead (LiPb) as breeder, neutron multiplier and tritium carrier, which is cooled by water at 15.5 MPa with an inlet temperature of 295℃ and an outlet temperature of 328℃.

Water flows in Double-Wall Tubes (DWTs) in order to reduce the probability of water/LiPb chemical interaction. In the case of a LOCA accident, multiple rupture of these tubes is postulated, with consequent leakage of pressurized water in the LiPb side of the module.

The present safety analysis has been performed with the MELCOR computer code (ver. 1.8.6) modified for the application in the fusion context. Custom models are employed to simulate the chemical water/LiPb interaction in the module. The rupture mass flow rate calculated in water simulation is transformed in its equivalent in terms of hydrogen and unreacted water steam. Both have been treated as non-condensable gas. Two different input decks, one for each fluid considered, have been coupled through an external interface to account for their reciprocal interaction.

Pressure and temperature transient behavior in the broken module demonstrate that safety margins are respected during the entire accidental sequence, even though no external safety system is foreseen or actuated. Moreover, particular attention has paid to the quantity of hydrogen produced in order to support the development of solutions, suitable for the DEMO, to prevent hydrogen explosion.

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