Assessment of Liquid Breeder First Wall and Blanket Options for the DEMO Design*

C.P.C. Wong[1], S. Malang[2], M. Sawan[3], S. Smolentsev[4], S. Majumdar[5], B. Merrill[6], D.K. Sze[7], N. Morley[4], S. Sharafat[4], P. Fogarty[8], M. Dagher[4], P. Peterson[9], H. Zhao[9], and S. Zinkle[8]

[1]*General Atomics, P.O. Box 85608, San Diego, California 92186-5608, wongc@fusion.gat.com*
[2]*Fusion Nuclear Technology Consulting, Linkenheim, Germany, Siegfried.Malang@iket.fzk.de*
[3]*University of Wisconsin, Madison, Wisconsin.*
[4]*University of California, Los Angeles, California.*
[5]*Argonne National Laboratory, Argonne, Illinois.*
[6]*INEEL, Idaho Falls, Idaho.*
[7]*University of California, San Diego, California.*
[8]*Oak Ridge National Laboratory, Oak Ridge, Tennessee.*
[9]*University of California, Berkeley, California*

As candidate blankets for an US DEMO power plant, we assessed first wall and blanket concepts based on the use of reduced activation ferritic steel (RAFS) as structural material and liquid breeder as the coolant and tritium breeder. The liquid breeder choice includes the eutectic lead-lithium alloy Pb-17Li and low melting point molten salts such as $LiBeF_3$ with a melting point of 380°C and FLiNaBe with a melting point of ~305+15°C. Molten salt blankets require additional neutron multiplier like Be to provide adequate tritium breeding. In order to meet the temperature limitation of RAFS with T_{max} < 550°C, while getting high coolant outlet temperature for high thermal efficiency, we selected the dual coolant configuration for our designs. Helium is used to remove the first wall surface heat flux and to cool the entire steel structure. The liquid breeder is circulated to external heat exchangers to extract the heat from the breeding zone (a "self-cooled" breeding zone). We take advantage of the molten salt low electrical and thermal conductivity to minimize impacts from the MHD effect and the heat losses from the breeder to the helium cooled steel structure. For the Pb-17Li breeder we employ flow channel inserts with a low electrical and thermal conductivity to perform similar functions. We based our first wall and blanket assessment on a DEMO design, which has a maximum neutron wall loading of 3 MW/m^2 and a maximum surface heat flux of 0.42 MW/m^2 at the outboard midplane of the tokamak reactor. This paper reports on the status and results of our assessment, including the logic behind materials and design configuration choices. Preliminary analyses including neutronics, thermal-hydraulics, thermal-mechanics, safety, tritium-control and power conversion system are presented. R&D items are also identified, which form the technical basis for the formulation of the US ITER test module program and corresponding test plan.

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