# Thermofluid Magnetohydrodynamic Issues for Liquid Breeders

Neil B. Morley[1], Siegfried Malang[2], Igor Kirillov[3]

[1]*Mechanical & Aerospace Engineering, UCLA, Los Angeles, CA, USA, morley@fusion.ucla.edu*
[2]*Consultant, Fliederweg 3, D 76351 Linkenheim-Hochstetten, Germany, smalang@web.de*
[3]*MHD-Machines Laboratory, D.V. Efremov Institute, 196641, St. Petersburg, Russia, kirillir@sintez.niiefa.spb.su*

Breeding blanket designs utilizing liquid breeder materials have been considered for fusion for many years. But since 1992, the only self-cooled blanket concept envisaged for tests in ITER was the lithium (Li) breeder/coolant, vanadium structure, coated insulator barrier concept. The situation has changed recently by the inclusion of self-cooled Molten Salt (MS) concepts and various "Dual Coolant" concepts with lead-lithium (PbLi) or MS as breeder/coolant. These new concepts have new magnetohydrodynamic-related (MHD) issues to be tested in ITER.

This paper provides a description of the most promising liquid breeder blankets currently proposed for testing in ITER, including:

(a) Self-cooled Lithium with vandium structure and insulator barrier,
(b) Separately-cooled PbLi with ferritic steel structure,
(c) Dual coolant PbLi with ferritic steel structure and SiC flow channel inserts, and
(d) Various incarnations of separately-cooled and dual coolant MS with ferritic steel structure.

The critical MHD issues for self-cooled and dual coolant liquid metal systems are the MHD pressure drop and flow distribution with ideal and imperfect insulator barriers/coatings, ideal and imperfect free-floating flow channel inserts, and complex geometry flow elements like expansions, contraction, manifolds, *etc*. Separately-cooled PbLi systems still must circulate the PbLi for tritium removal, and similar MHD issues may limit the flow velocity and influence the tritium permeation due to creation of stagnant regions and other non-ideal flow distribution effects. Molten salt breeder/coolants have significantly reduced electrical conductivity as compared to liquid metals and MHD pressure drop is not considered a serious issue. However, MS also have much lower thermal conductivity as well, and the heat transfer to/from the structure depends on turbulent convection. The degradation of convective heat transfer by MHD turbulence modification/suppression is of great interest for both self-cooled MS systems where first wall cooling may need to be enhanced, and dual coolant MS systems where heat transfer from the hot breeder to the cooler wall needs to be suppressed.

An assessment is provided as to which of these MHD-related issues of liquid breeder blankets can be investigated in ITER, along with a discussion of the strong points and limitations of MHD-related tests in ITER. A coordinated plan is evolved for testing needed prior to ITER, tests conducted during the first ITER phase with no neutrons, and later phase tests coupled to heat transfer effects and the thermomechanical loading of structures with electroinsulating barriers/coatings and inserts.