Overview of the Current Progress on the US Liquid Metal Plasma Facing Component Design Program

D. Andruczyk[a], D. Curreli[a], J. Jun[b], J. D. Lore[b], C. E. Kessel[b], A. Khodak[c], E. Kolemen[c], R. Maingi[c], D. O'Dea[a], B. A. Pint[b], R. Rizkallah[a], A. Shone[a], S. Smolentsev[d], Z. Sun[c] and D. L. Youchison[b]

[a]University of Illinois Urbana-Champaign, Urbana, IL, USA

[b]Oak Ridge National Laboratory, Oak Ridge, TN, USA

[c]Princeton Plasma Physics Laboratory, Princeton, NJ, USA

[d]University of California Los Angeles, Los Angeles, CA, USA

e-mail (speaker): andruczy@illinois.edu

In 2019 the U.S. Department of Energy initiated a liquid metal divertor plasma-facing component (PFC) design program to initiate design a pre-conceptual design for a flowing liquid metal divertor for a Fusion Nuclear Science Facility (FNSF). The program has three parallel activities that are complimentary to each other. The first is design calculation of the liquid metal flow and heat transfer for potential PFC designs; the second is closing gaps in liquid metal technology and science gaps with experiments in test stands; and the third is experiments using linear flow configurations with applied magnetic fields for LM MHD model validation and PFC concept development. Several calculations have concluded that to remove 10 MWm^{-2}, liquid lithium flow speeds of 5 – 10 ms^{-1} are needed. Cooling of the system has also been analyzed with different heat removal regimes and cooling liquids. Preliminary calculations of plasma response to the liquid Li PFC were also initiated with the SOLPS code, as well as detailed sheath modeling with the HPIC code, and lithium vapor cloud modeling using the ZAPDOS-CRANE platform. ZAPDOS is a finite element solver and CRANE is a plasma chemistry network solver. Experiments have been performed and are still underway to look at material corrosion, erosion, wetting capability and efficient distribution across a flow surface. A lithium injection system has been developed, and measurements to benchmark the vapor cloud are also underway. These test-stand experiments are being led and performed by Illinois and ORNL; new experiments are being performed on LMX at PPPL to study flowing (~1 ms^{-1}) liquid galinstan for flow uniformity and surface wave formation, hydraulic jumps, and heat transfer. * Sponsored by the U.S. Department of Energy.