Project Code: PDF – FT - 0010	
Title of the Project	Design, analysis and fabrication of Pb-16Li/Helium heat exchanger
Abstract	Lead-Lithium alloy is used as the coolant and tritium as breeder material in liquid breeder blankets. During the blanket operation, the hot Pb-Li coming out of the blanket at~>450˚C is required to be cooled to 300 ˚C before sending it back to the blanket and this is accomplished by a heat exchanger in the system. Gaseous helium is considered to be the secondary coolant for the heat exchanger. Hair pin type, shell and tube, and printed circuit heat exchangers are currently under consideration for this purpose. This Lead- Lithium to helium heat exchanger is required to extract heat from Pb-Li Eutectic alloy and transfer to Helium which will be further cooled by water and fed back to the heat exchanger. This Heat exchanger has to be designed and developed to meet all the functional requirements and to withstand high temperature and pressure conditions of the alloy. Feasibility of maintenance of the heat exchanger during service is also an important requirement. It has been planned to accomplish the project target in two phases. In the first phase of the project (current proposal) following major activities will be performed : • Selection of proper Heat Exchanger considering the above mentioned aspects. • Thermal and Mechanical

	Design of Pb-16Li/ Helium HX and its thermo-hydraulic analysis using commercial/open source software like ANSYS/COMSOL/Open FOAM etc. Fabrication of the Pb-16Li/Helium heat exchanger through vendor
Research Focus Area	The development and successful testing of Lead - Lithium to helium Heat exchanger is considered to be an important milestone to be achieved for Pb-Li technology development towards the liquid breeder blanket. At IPR, as an initial efforts towards the development of liquid metal heat exchanger, a Pb-16Li/ Thermic fluid heat exchanger of capacity~24kW has been designed, developed and tested in Pb-16Li loop. The HX was operated within a temperature range of 300-315°C, which is within the safe operating temperature for the coolant Therminol-55. To test the Pb-16Li heat exchanger under high-temperature (450°C and above) blanket conditions, the design and development of a Pb-16Li/Helium heat exchanger has been proposed.
Qualification	Ph.D. in Mechanical Engineering
Desired Experience	Working knowledge in the design and thermo-hydraulic analysis of heat exchangers/mechanical components
Remarks	The IPR has the following process fluid, components, diagnostics and coolant system required for the performance testing of the Pb-Li/He heat exchanger after its

	fabrication A. Pb-16Li inventory of ~500kg B. Pb-Li pump for circulation of the Pb-Li in the system C. MHD flow meter for the Pb-16Li flow measurement D. Circulation type heater to provide continuous heat load to Pb-16Li during testing of the HX E. Experimental Helium Cooling Loop (EHCL) to extract the deposited heat from Pb-16Li in Pb-16Li/Helium heat exchanger Some relevant literatures related to the liquid metal heat exchanger and facilities developed at IPR is provided below References: 1. A. Deoghar et.al, Preliminary Assessment of the Operational Performance of the Pb-16Li Heat Extraction System, FUSION SCIENCE AND TECHNOLOGY · VOLUME 81 · 384–395 · JULY 2025 2. B.K. Yadav et.al, Overview of the Experimental Helium Cooling (EHCL) system, Fusion Engineering and Design, Volume 196, November 2023, 114006 3. K. Cheng et.al, Comprehensive performance assessment on LBE-helium heat exchangers for the ADS based on extension theory, Case Studies in Thermal Engineering, Volume 53, January 2024, 103793

	4. Numerical study on the heat transfer characteristics of a liquid lead–bismuth eutectic in a D-type channel, Front. Energy Res., 09 November 2022, Sec. Nuclear Energy Volume 10 - 2022 | https://doi.org/10.3389/fenrg.2022.1041900 5. Iván Fernández et.al, Design analysis of a lead–lithium/supercritical CO2 Printed Circuit Heat Exchanger for primary power recovery, Fusion Engineering and Design, Volume 88, Issues 9–10, October 2013, Pages 2427-2430