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量研におけるIFMIF/EVEDA中性子原設計の現状
Current status of IFMIF/EVEDA neutron source design activities at QST

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Introduction

The fusion neutron source (FNS) design activity has been implemented as BA Phase II of the IFMIF/EVEDA project since 2021. As a result of discussions between QST and F4E, it was determined that the FNS design studies related to the safety should be prioritized, and the following items were decided to implement by QST and F4E,

i) Tritium migration estimation,
ii) Erosion/deposition modelling in the lithium loop,
iii) Accident analysis in Safety,
iv) Study on the optimization of the Li-Oil Heat Exchanger,
v) Use of LIPAc as testing facility.

Tritium Migration Estimation

Huge amount of tritium are generated in the liquid Li with Li(d,tx) and Li(n,tx) reactions and are trapped in hydrogen trap system. Certain amounts of tritium that are not captured by the trapping device remains in liquid lithium and eventually permeates through the structural material and vaporize into vacuum. The purpose of this task is to evaluate the amount of tritium leaking out and to review the specification requirements for detritiation. From the evaluation results, it was found that the amount of tritium as hydrides in lithium in the vapor/mist trap is much higher than the others. The amount of tritium dissolved in structural material in the EMP was largest among whole components of Lithium Facility, since it has large center-core in its structure.

Erosion/Deposition Modelling (EDM)

The issue of EDM is to study the dose from radioactivity in lithium. In particular, the evaluation of effective dose rate is important data for maintenance and replacement work related to the target system. The dose rate due to the activated erosion products were evaluated. The total source term in the F82H back plate has been estimated using by Monte Carlo transport code MCNP and inventory calculation code FISPACT. The most conservative erosion/deposition model was created, and the deposition amount was calculated as 0.079 g. Based on the amount, the activity, the contact γ-dose rate, and the dose rates around the point source as a function of the distance were evaluated. These values were found to be much higher than the hands-on criteria of 10 microSv/h.

Accident analysis in Safety

The activities consist of three issues: failure mode analysis, safety control systems and the Material at Risk (MAR). As part of MAR, we newly developed a tritium diffusion code for tritium emitted from a fusion neutron source facility and tested the code to validate one. The code was developed based on the puff-Gauss model, which is capable of faithfully analyzing tritium diffusion in unsteady field condition. This code enables diffusion analysis using actual meteorological and topographical data, which were not applied in conventional plume model analysis codes.

Li-Oil Heat Exchanger

The primary heat exchanger system HX1 for liquid lithium target was redesigned. HX1 uses an oil heat transfer fluid for cooling lithium, and Therm-S900 (Hydrogenated terphenyl: C18H22) has been considered as a candidate material in IFMIF design activity. Therm-S900 is not applicable to HX1 because it is a toxic oil under Japanese regulations. Therefore, QST has been considering alternative materials with less environmental impact. As a result of the study, QST propose that dibenzyl toluene (C21H20), which has lower toxicity, is one of the most promising materials.

Use of LIPAc as testing facility

As for the item "Use of LIPAc as testing facility", we aim to obtain R&D data for designing an accelerator for a fusion neutron source in conjunction with the beam operation of the prototype accelerator LIPAc being developed at Rokkasho Fusion Institute. We will reflect the data by LIPAc operation such as RAMI, activation, neutonics to the FNS design.