Estimation of Radioactivities in the IFMIF Liquid Lithium Loop due to the Erosion and Corrosion of Target Back-wall

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International Fusion Materials Irradiation Facility (IFMIF) is an intense neutron source for testing materials that will be used to construct fusion reactors. Neutrons are generated through deuteron-lithium (Li) stripping reactions. In the design of the facility, the liquid Li target will be bombarded by deuterium beam with the power at 10 MW to produce a great amount of neutrons so that materials will be irradiated up to the level of 50 dpa/y. Through this process, a mass of radioactive remnant ^{7}Be is produced in the liquid. In addition, surrounding structural materials are extremely activated by the neutrons, which causes several adverse effects for the maintenance work. One of the effects is caused by erosion and corrosion of the target back-wall, through which activated compositions move into liquid lithium. Since the lithium flows in pipes along the lithium lines, the activated erosion/corrosion products are transported everywhere in the loop and accumulate as the operation goes on. The radiation dose rate becomes higher as the activation build-up grows, and the level drastically affects the strategy for the maintenance works around the Li loop. The half- lives of the activities are relatively large compared with reaction remnants, and the effect has not been studied yet in the IFMIF design. In the present work, the radioactivity in the Li loop was estimated and the influence on the maintenance scenario was assessed.

The neutron spectrum in the back-wall was calculated by McDeLicious, an extended version of a Monte Carlo transport code MCNP, to sample source neutrons based on the deuteron-lithium reaction cross section data. The activation reaction rate of the back-wall was calculated based on the IEAF-2001 library, the latest version of nuclear activation data in the intermediate energy range up to 150 MeV compiled in Europe for the design of accelerators. The activation build-up during the operation and the decay after shutdown were calculated by the ACT-4 code of the THIDA-2 system, a design code system for fusion reactors developed in JAERI. The material of the target back-wall is the stainless steel type 316, and the total amount of radioactivity in the back-wall was calculated to be 2×10^{18} Bq/m^3 (several tens Ci/cc) one month after the shutdown. The radioactivity in the IFMIF Li loop was evaluated under the erosion and corrosion rate at 1 μm/y based on the data in FMIT project. The area of stainless steel that suffers erosion and corrosion is 100 cm^2, which is as large as the beam footprint on the back-wall. Thus, the total amount of the activity after one-year operation was calculated to be 2×10^{10} Bq (some 1 Ci). On the other hand, the amount of the deuteron-lithium reaction remnant ^{7}Be would be as much as 4.5×10^{15} Bq (about 10^5 Ci) during the maintenance work according to the result of the IFMIF design activity. As a result, the radioactive compositions in Li loop supplied by the erosion and corrosion of the target back-wall turned out to be negligibly small compared with that of reaction remnants.