NOVEL METHODS OF TRITUM PRODUCTION RATE MEASUREMENTS IN HCLL TBM MOCK-UP EXPERIMENT WITH LIQUID SCINTILLATION TECHNIQUE

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Neutronic codes and nuclear data need independent validation in order to assure reliable results when applied in design calculations. Validation of calculations for the Test Blanket Modules (TBM) design based on the Helium Cooled Lithium Lead (HCLL) concept is achieved through integral benchmark experiments in which mock-ups are irradiated with 14 MeV neutrons and nuclear responses to the irradiation are measured, and compared to the model calculations simulating maximum closely the experimental set-up.

Two novel methods of tritium production rate (TPR) measurements applied in HCLL TBM mock-up neutronic experiment are described and discussed. In the first method LiF TLD detectors commonly used for gamma radiation dose measurements are applied. Tritium produced by neutrons after $^{-}\beta$ decay leads finally to accumulation energy within TLD detector. This phenomenon is exploited for measurement of the tritium activity generated in the detector material [1]. The TL signal read-out in standard procedure corresponding to the deposited energy usually is expressed as mGy/h. Recalculation to Bq/mg requires calibration by independent measurement of ^{3}H activity generated in the TLD. In our experiments determination of this activity was performed by LSC technique. Good correlation between the ^{3}H activity and TLD signal was observed in the investigated range: 0.5 – 25 Bq/mg of LiF (2μGy/h - 120 μGy/h).

The second presented method consists of direct measurement of ^{3}H in LiPb material with the use of LSC technique. Dissolution of LiPb in nitric acid, and than composing aliquot containing well known mass of irradiated LiPb mixed than with scintillation cocktail, is measured in LS spectrometer providing signal proportional to the ^{3}H activity. It was proved by series of experiments that procedure performed at controlled conditions ensures no loss of tritium while preparation. Optimization measurement conditions with respect of type of the scintillation used and composition of aliquot / scintillator mixture provides counting efficiency above 22%. Sample material for testing the both techniques was irradiated by neutron flux either at nuclear research reactor “Maria”, Świerk, Poland or at the Frascati Neutron Generator Laboratory, Italy. Also Li_2CO_3 pellets were irradiated in the same experiment with TLDs, and samples of LiPb-eutectic and analysed by modified Diercx method [2], a well established technique. They were used as reference samples. Measurement results we obtained applying the both techniques described above as well as the control Li_2CO_3 pellets were in very good consistency. Direct measurement of ^{3}H produced in LiPb by neutron flux seems to be the very promising and relatively simple method of validation of neutronic codes and nuclear data capabilities to calculate tritium production rate in fusion relevant materials.

[1] Pohorecki,W., et al., Thermoluminescent method for the measurements of tritium production in neutronics experiments, Radiation Measurements (2010), doi:10.1016/j.radmeas.2009.12.020 (in press).

[2] R. Dierckx, Direct tritium production measurement in irradiated lithium, Nuclear Instruments and Methods, Volume 107, Issue 2, 1 March 1973, Pages 397-398