Nuclear Data and neutronics study for Long-lived Radionuclides (A ~ 50-60) in Fusion Reactor Technology

Jyoti Pandey[1], Bhawna Pandey[2], H.M. Agrawal[2], P.V. Subhash[1], S. Vala[3], Rajnikant Makwana[4], S.V. Suryanarayana[5], S. Santra[5]

[1] ITER-India, Institute For Plasma Research, DAE, Government of India, Bhat, Gandhinagar-382428, Gujarat, India.
[2] Govind Ballabh Pant University of Agriculture and Technology, Pantnagar , Uttarakhand, India
[3] Institute for Plasma Research, Fusion Neutronics Laboratory, Gandhinagar, Gujarat 382428,India
[4] M.S. University of Baroda, Physics Department, Faculty of Science, Vadodara, Gujarat 390002, India
[5] Bhabha Atomic Research Centre, Nuclear Physics Division, Mumbai, Maharashtra 400085, India

High quality nuclear data for upcoming fusion reactor is one of the fundamental pre-requisites in order to model the reactor designing and to predict the activation heating, shielding and material damage induced by nuclear reactions. Nowadays there is a greater demand for the Cross-sections and Activation data for long-lived radioisotopes in the mass region A~50-60 and their impact in Fusion Reactor Technology. Long-lived radionuclides in the mass region 50-60 may be of great concern from the view point of the radioactive nuclear waste, enhancement of extra helium and hydrogen generation during reactor operation, which may affect the neutronics of the fusion reactor up to certain extent. Present study highlights the need, impact and first time experimental measurement of cross-section performed specially for the long-lived radionuclides in the medium mass region. Landmark steps which have been taken in this direction includes : (i) the measurement of neutron induced cross-section of radionuclide ^{59}Ni(n,xp) by surrogate ratio method (ii) estimation of the amount of radionuclides formed in fusion reactor environment through different pathways using activation calculations (iii) impact of radionuclides on reactor material i.e. primary knock on atom spectra, number of He and H atoms produced at critical components of the fusion reactor (iv) Neutron transport calculation for a fusion system (v) Activation calculations for structural material of reactor. The surrogate reaction ratio technique has been used for the charged particle emission reaction. Because of the discrepancy in the available nuclear data libraries more experimental measurements are required. The surrogate ratio method can be benchmarked with the reactions that have direct measurement. The accuracy of the deduced cross-section is now well known for certain ranges of incident neutron energy. TALYS-1.8 code has been used to calculate (n,H) (n,He) reaction cross section on ^{55}Fe, ^{59}Ni from 1 keV to 20 MeV. On the basis of the excitation functions, there is an anomalous behavior and therefore it is recommended to include the lower energy neutron induced cross-section calculation with nuclear reaction modular codes TALYS and EMPIRE. It is concluded that the present study contributes substantially to improving the knowledge of the neutron cross-sections, activation and damage data mainly for the long-lived radionuclides which are important to fusion reactor design.