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Activation and Radiation Damage Behaviour of Russian Structural Materials for Fusion Reactors in the Fission and Fusion Reactors (P4-I-433)

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Various structural low (reduced) activated materials have been proposed as a candidate for the first walls-blankets of fusion reactors. One of the main problems connected with using these materials - to minimise the production of long-lived radionuclides from nuclear transmutations and to provide with good technological and functional properties. The selection of materials and their metallurgical and fabrication technologies for fusion reactor components is influenced by this factor. Accurate prediction of induced radioactivity is necessary for the development of the fusion reactor materials.

Low activated V-Ti-Cr alloys and reduced activated ferritic-martensitic steels are a leading candidate material for fusion first wall and blanket applications. At the present time a range of compositions and an impurity level are still being investigated to better understand the sensitive of various functional and activation properties to small compositional variations and impurity level.

For the two types of materials mentioned above (V-Ti-Cr alloys and 9-12% Cr f/m steels) and manufactured in Russia (Russia technologies) the analysis of induced activity, hydrogen and helium-production as well as the accumulation of such elements as C, N, O, P, S, Zn and Sn as a function of irradiation time was performed. Materials “were irradiated” by fission (BN-600, BOR-60) and fusion (Russian DEMO-C Reactor Project) typical neutron spectra with neutron fluency up to 1022 n/cm2 and the cooling time up to 1000 years. The calculations of the transmutation of elements and the induced radioactivity were carried out using the FISPACT inventory code, and the different activation cross-section libraries like the ACDAM, FENDL-2/A and the decay data library FENDL-2/D.

It was shown that the level of impurities controls a long-term behaviour of induced activity and contact dose rate for materials. From this analysis the concentration limits of impurities were obtained. The generation of gas and solid transmutants can play a large role in changing of the properties of alloys to irradiation. Neutron-induced transmutations lead to substantial changes in elemental composition. Especially, for vanadium material the large level of solid transmutation occurs both in fission and fusion spectra. The obtained results give a complete picture about the values of induced radioactivity, dose rate, decay heat, element and gas production.