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ACTYS Code System: Towards Next Generation Nuclear Activation Codes for Fusion Reactors

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Nuclear activation and subsequent radiological response of structural materials within fusion reactors like ITER and beyond need to be studied for operational, safety and radiological waste management reasons. The future fusion machines should be equipped with low radioactive materials optimized for expected neutron environment. Numerical tools with extended capabilities are needed for this kind of analysis. A project named ACTYS-Project is initiated at Institute for Plasma Research to meet the requirements stated above. This effort so far developed more than five states of art codes and few innovative computational tools for analysis and design of fusion reactors. The details of all the codes and tools will be presented in this paper. ACTYS is the first code within the project. It is a single-point neutron activation code and computes nuclide inventories and other radiological responses within materials when exposed to neutron flux through either continuous, pulse irradiation or mixed. It solves coupled first-order LODEs using Bateman solution for linearized chains. An 'exponential convergence'algorithm and 'chain weighing'termination technique is developed in-situ for this purpose. These two methods lend ACTYS an added edge over typical linear chain solvers. ACTYS is well validated and the details of the same will be presented. Highly resolved nuclear activation analysis and radiation waste classification are warranted for large-sized fusion machines with a wide variety of materials. To ensure a fast multi-point activation analysis without sacrificing accuracy, inherent changes must be done to single-point activation codes like ACTYS. To this end, a multipoint activation code-named ACTYS-1-GO is developed. Recently, it has been coupled with transport code ATTILA by developing a subsidiary module, activation source generator. One of the important features is that nearly 1 million meshes can be computed in less than few hours. A mathematical formulation to account for the contribution of the parent constituents of any irradiated material towards the radiological responses was derived and implemented. The first order derivatives of Bateman linear chain solution with respect to the decay and cross sections constants are generally used for the sensitivity analysis. A simplified and improved set of recursive relations are developed for these derivates.

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Author: Dr P.V, Subhash (ITER-India, Institute for Plasma Research, Gandhinagar, Gujarat)

Co-authors: Ms KANTH, Priti (Institute for Plasma Research, HBNI); Prof. DESHPANDE, Shishir.P (ITER-India, Institute for Plasma Research); Dr R, Srinivasan (Institute for Plasma Research); Mr TADEPALLI, sai chaitanya (ITER-India, Institute for Plasma Research)

Presenter: Dr P.V, Subhash (ITER-India, Institute for Plasma Research, Gandhinagar, Gujarat)

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