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Calculational-Experimental Approach of Radiation Damage Parameters on VVER Equipment Evaluation

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Abstract : The problem of ensuring of VVER type reactor equipment integrity is now most actual in connection with justification of safety of the NPP Units and extension of their service life to 60 years and more. First of all, it concerns old units with VVER-440 and VVER-1000. The justification of the VVER equipment integrity depends on the reliability of estimation of the degree of the equipment damage. One of the mandatory requirements, providing the reliability of such estimation, and also evaluation of VVER equipment lifetime, is the monitoring of equipment radiation loading parameters. In this connection, there is a problem of justification of such normative parameters, used for an estimation of the pressure vessel metal embrittlement, as the fluence and fluence rate (FR) of fast neutrons above 0.5 MeV. From the point of view of regulatory practice, a comparison of displacement per atom (DPA) and fast neutron fluence (FNF) above 0.5 MeV has a practical concern. In accordance with the Russian regulatory rules, neutron fluence F(E > 0.5 MeV) is a radiation exposure parameter used in steel embrittlement prediction under neutron irradiation. However, the DPA parameter is a more physically legitimate quantity of neutron damage of Fe based materials. If DPA distribution in reactor structures is more conservative as neutron fluence, this case should attract the attention of the regulatory authority. The purpose of this work was to show what radiation load parameters (fluence, DPA) on all VVER equipment should be under control, and give the reasonable estimations of such parameters in the volume of all equipment. The second task is to give the conservative estimation of each parameter including its uncertainty. Results of recently received investigations allow to test the conservatism of calculational predictions, and, as it has been shown in the paper, combination of ex-vessel measured data with calculated ones allows to assess unpredicted uncertainties which are results of specific unique features of individual equipment for VVER reactor. Some results of calculational-experimental investigations are presented in this paper.

Keywords : equipment integrity, fluence, displacement per atom, nuclear power plant, neutron activation measurements, neutron transport calculations

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