### Status of the ISTC project proposal on “Study of fission products release and behaviour of VVER fuel with high burnup under severe accident conditions (VERONIKA)”

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### ABSTRACT

The necessary condition to increase the nuclear power plants safety it is a creation of reliable physical models and codes able to describe the behaviour of fission products (FP) in the uranium dioxide matrix and their release to the containment at high temperatures and a wide spectrum of environmental conditions (a various steam concentrations in presence of hydrogen formed as a result of a steam-zirconium reaction). Taking into account a variety of the possible beyond-design-basis accident conditions with severe fuel damage the decision of this problem is possible only on the basis of model-based analysis.

One of the codes modeling the FP release is a MFPR code. The physical models implemented in the MFPR code allow describing all set of the FP release processes including diffusion of FP atoms in the crystal lattice, formation and migration of gas bubbles to the grain boundaries, their coalescence, formation of open porosity and release from fuel. Mechanistic character of the models implemented in the code assumes necessity of verification against the test results of both separate mechanisms and integrated results of calculation.

The purpose of the VERONIKA Project is the realization of the tests aimed at the acquisition of data necessary for the perfection of the MPFR code physical models describing FP behavior in a crystal lattice and verification of the calculation results

The Project structure includes three interrelated tasks:

manufacturing of the installation for the FP release examination at temperatures

up to 2300 °C in oxidizing and a reducing conditions;

realization of the tests using the uranium dioxide with high FP concentration;

improvement of the models implemented in MPFR code on the base of obtained results.

The experimental part of the Project includes tests on examination of the FP release from irradiated uranium dioxide that will allow verification of the code models considering matrix microstructural parameters by means of the comparison of experimental and calculated results.

For the acquisition of data necessary for verification of the code diffusion models the tested samples will be subjected to an additional short-term irradiation at a low temperature. The purpose of an additional irradiation consists in accumulation of low concentration of short-lived FPs in solid solution in the uranium dioxide matrix. Experimental release kinetics will allow the verification of all the set of code models from diffusion of separate atoms to their release through a network of porosity both formed as a result of the base irradiation and developing as a result of heating up to temperatures, characteristic for the beyond design basis accident. Planned tests in oxidizing and reducing environments are aimed for definition the influence of fuel stehiometry on the model-based diffusion processes During the offered Project ten tests will be executed.

Owing to essential influence of structure modifications (formation of the open and closed porosity, and inclusions influencing moving of gas bubbles) on a FP release the extensive program of post-test examination of uranium dioxide structure is planned in the experimental part of the work. A main objective of examinations is the detailed definition of morphology of porosity, as a key parameter influencing FP release and predicted by code (verification of results of calculation). The estimation of the inclusions structure and morphology formed in the uranium dioxide matrix at high-temperature heating, also will allow the verification of code diffusion models.

The variation of parameters (temperature, environment) of the planned tests having a character of parametrical tests, does not cover all possible range of the beyond-design-basis accident conditions which generally are not well known, but the obtained data will allow improving the code physical models and to raise the reliability of code predictions.