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Targets for NPPs to Ensure Their Competitiveness in the World Market

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The targets for NPP used for reactor facility development and NPPs design are considered: LCOE and TCIC and indicative parameters. The first indicator determines the conditions for NPP break-even operation within its service life. The second indicator is necessary to reduce the total capital investment cost of NPP. The conditions for the competitiveness have been confirmed: LCOE should be less than LCOE of running facilities; TCIC – less than 0,8 $TCIC_{min}$ of operating NPPs. The indicative parameters (indicators) for implementation of mandatory (imperative) parameters are proposed.

Key Words: reactor, NPP, competitiveness, prime cost.

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Study of Properties of DDL-Schemes of Discrete Ordinate Method as Applied to Calculation of Two-Dimensional Grid Problems with Arbitrary Quadrilaterals

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The results of assessment of the error of two-dimensional DDL-schemes of discrete ordinate method for arbitrary quadrilateral subchannels are presented.

Key Words: DDL-schemes, arbitrary quadrilaterals, methodical error.

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Analysis of the Calculation Results of the Conditions with Steamline Break of VVER RP in Rod-to-Rod Approximation Using SP KORSAR/GP

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One of the decisive accidents in the VVER RP safety analysis is the steamline break accident. At the first initial stage as a result of the initiating event the secondary-side steam-water mixture outflowing into the break begins, which results in a quick pressure decrease on the secondary side and an increase in the heat flux removed from the primary circuit. It leads to coolant temperature decrease at the core inlet which causes power increase due to the effect of the feedbacks. At this stage of the accident the maximum values of fuel temperature and specific enthalpy are reached. The scram brings the reactor into subcritical state. The first stage of the accident was modeled in the study. An estimation of the maximum values of fuel temperature and enthalpy was made with a rod-to-rod FA model. The results were compared with the results obtained in the “hot channel” approximation. The calculations were performed for different initial states of the power plant. A realistic and conservative RP initial states were considered. Recommendations were developed on the application of the rod-to-rod FA model for the given accident.

Key Words: rod-to-rod FA model, KORSAR/GP, VVER RP, steamline break, realistic approximation, conservative approximation.

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The Use of Statistical Procedures when Estimating the Number of Plugged Tubes of Steam Generator

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Lifetime management (LM) of a steam generator requires the development of procedures for predicting the number of plugged heat exchanging tubes of steam generators (SG PHET) using various approaches - both physical and statistical and just statistical. The method for predicting the number of PHET of a steam generator of nuclear power plants with VVER-1000/1200 on the basis of Weibull distribution is proposed in the present document. Algorithms of the method for predicting are justified and developed, and assessments of the Weibull distribution coefficients are obtained by the maximum likelihood method (MLM) and by the least square method (LSM) on the basis of the statistical data on SG PHET. In addition, regression curves were plotted by the data on plugging for which 95 % confidence intervals were calculated. The comparison of the prediction results with the model based on regression is provided. Weibull assessments are shown to become excessively conservative with the predicting interval of more than 5 years.
Key Words: heat-exchanged tubes, steam generator, maximum likelihood method, least square method, calculation of Weibull distribution coefficients, statistical regression.

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Calculational and Experimental Justifcation of Semi-Empirical Correlations for Determination of Thermodynamic and Transport Properties of Liquid Bismuth

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The new calculational ratios are proposed for evaluation of density, thermal conductivity coefficient, surface tension coefficient, sound velocity, heat capacity coefficient, specific electrical resistance and dynamic viscosity coefficients of liquid bismuth based on the calculational analysis of experimental data provided in the 78 experimental work in Russia and abroad for the period from 1950 to 2019 years. The error values of proposed ratios and the range of their applicability are provided. The paper was prepared by the results of work of Thermodynamic Properties Data Center (TPDC) of State Atomic Energy Corporation “Rosatom”.
Key Words: bismuth, coolant, density, thermal conductivity, heat capacity, viscosity, thermodynamic properties, transport properties.

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Experimental Studies of Core Refooding Using the TVS-2M Fuel Assembly Model with Mixing Grids

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The article presents the description of experimental facility, procedure of the experiments, as well as the results of experimental studies simulating the processes of VVER-1000 core reflooding using the TVS-2M both with mixing grids “Vihr” and “Progonka” and without mixing grids under conditions of large break LOCA. The experiments were performed at OKB “GIDROPRESS” at the fuel assembly model with 127 rods. Based on the results of experiments a comparative assessment of influence of “Vihr” and “Progonka” mixing grids on core reflooding dynamics was performed.

Key Words: experimental studies, reflooding, mixing grids, fuel assembly.

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Experimental Studies of Coolant Mixing in the Fuel Rod Bundle

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The article presents the description of experimental facility, procedure of the experiments, as well as the results of experimental studies simulating the inter-subchannel mixing processes in the fuel rod bundle in single-phase coolant flow. The experiments were performed at OKB “GIDROPRESS” at the FA coolant mixing test bench using the cross section-full scale fuel assembly model. Based on the results of experiments an assessment of natural inter-subchannel exchange intensity in the fuel rod bundle with single-phase flow was performed in comparison with hydraulically isolated subchannel simulating “hot jet” calculated assumption.

Key Words: coolant mixing, single-phase flow, fuel assembly.

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Tests of Absorbing Element Mockups with Boron Carbide in Chromium-Nickel Alloy ЭП-630У Claddings in the Cooling Crisis Conditions

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The conditions and results of in-pile tests of VVER absorbing element mockups with a cladding made of a chromium-nickel alloy and an absorber – boron carbide in the form of powder and a pellet are considered. The temperature conditions corresponded to the conditions close to the anticipated operational occurrences and accident conditions. When analyzing the results, the data was used from previously performed tests of irradiated fuel rods with a similar chrome-nickel cladding.

Key Words: absorbing element, chromium-nickel alloy, boron carbide, reliability.

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The Results of Thermal Tests of Irradiated Fuel Rods with Claddings Made of 42CrNiMo Alloy

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In JSC “SSC RIAR” thermal tests of shortened fuel elements with claddings of chromium-nickel alloy 42CrNiMo previously irradiated in the irradiation device “Garland” of the MIR reactor up to build up of fission fragments of 0.9 g/cm^3 were conducted. The mechanism of unsealing of fuel rods was determined. Unsealing is connected with changes which occur in the core of the fuel rods at increased temperatures, whereas in the chromium-nickel 42CrNiMo claddings with holding time during an hour at 600 °C, there are practically no structural changes. The dependence was obtained which allows to estimate whether the unsealing of the fuel rod will take place at a given temperature and, if it does, then to estimate the time before unsealing.

Key Words: thermal testing, chromium-nickel alloy, fuel rod, cladding, 42KhNM.

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Studies of Heat Transfer at Supercritical Water Pressure Carried out at SSC RF – IPPE

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This paper presents a brief review of the work on heat transfer at supercritical pressure (SCP) in round tubes and rod bundles, performed at different time at SSC RF – IPPE. The description and technical characteristics of thermohydraulic test benches are provided, on which studies of heat transfer at supercritical parameters of water in round tubes (SVD-1 and SVD-2) and supercritical parameters of Freon-12 (STF) were carried out. The technical approach and methodology of the planned experimental researches of hydrodynamics and heat transfer under SCP are presented and discussed.

Key Words: nuclear reactor, supercritical pressure, experimental studies, heat-transfer test benches, tube, fuel rod bundle, water, freon, hydraulic resistance, heat transfer, heat transfer conditions, power-cooling mismatch interface.