

## Abstracts

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### Experience in Extension of Service Life for NRR BOR-60 – the Pledge of Development of “Fast Sodium” Technologies

*M.D. Lyakisheva, S.L. Lyakishev, V.M. Makhin, V.P. Semishkin,*  
JSC OKB "GIDROPRESS", 21 Ordzhonikidze Str., Podolsk, Moscow Region, 142103

**On the occasion of the 50th anniversary of research reactor plant BOR-60**

The paper presents the main outcomes of activity of OKB “GIDROPRESS” – the Chief Designer of NRR BOR-60 - for a period of extension of the assigned service life.

*Key Words:* fast reactor, sodium, service life extension

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### Water-Cooled Reactor Plants with Spectral Reactivity Control

*V.M. Makhin, I.V. Makhin, N.V. Shary,*  
JSC OKB "GIDROPRESS", 21 Ordzhonikidze Str., Podolsk, Moscow Region, 142103;

The paper deals with consideration of water-cooled reactor plant with spectral control of reactivity charge. Possible methods of spectral control are described including those used in practice (ABWR). Principal objectives in designing the water-cooled reactor plant with spectral control are to:

- reduce consumption of natural uranium in an open fuel cycle;
- provide efficient usage of neutrons by means of abandonment of chemical and boron control during fuel cycle;
- reduce liquid radwaste as a result of abandonment of boron control;
- provide a capacity to operation in a closed fuel cycle with core loading by MOX-fuel with high breeding ratio ( $K_B \sim 0,7-0,8$ , instead of  $0,3-0,4$  for operating WWER).

*Key Words:* reactivity, neutron spectrum

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### Specific Solutions for BRS-GPG-type Reactor Circuit of Low- and Medium-Power Plants with Lead and Lead-Bismuth Coolants

*A.V. Beznosov, T.A. Bokova, P.A. Bokov, N.S. Volkov, A.A. Karbyshev,*  
Nizhny Novgorod State Technical University n.a. R.E. Alekseyev, 24 Minin str., Nizhny Novgorod, 603950

The paper presents new engineering solutions for the BRS-GPG-type reactor circuit which are differ from transportable and stationary reactor plants of low- and medium-power with heavy liquid-metal coolants and which correspond to evolution of such plants. While developing these solutions we made use of the gained experience in designing and operation of Soviet pilot and commercial power plants cooled with lead-bismuth coolants and in investigations, primarily, experiments carried out at the Nizhny Novgorod State Technical University n.a. R.E. Alekseyev (NNSTU) to justify the capacity range (50-250 MW) proposed and studied at the NNSTU for low and medium-power reactor plants with horizontal steam generators (BRS-GPG).

*Key Words:* reactor, coolant, lead, lead-bismuth.

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**Results of Application of the Least Error Method in Positioning the Detection Units of Neutron Flux Monitoring Equipment over the Height of Instrumentation Tube**

*A.A. Tomilin, M.A. Uvakin, A.I. Sinegribova, A.A. Semenov,*

JSC Experimental & Design Organization «GIDROPRESS»,

21, Ordzhonikidze St., Podol'sk, Moscow Region, 142103;

National research Nuclear University "MEPhI", 31 Kashirskoe road, Moscow, 115409

The paper deals with consideration of the results of application of the least error method in positioning the ex-core detection units (DU) of neutron flux monitoring equipment (NFME) over the height of instrumentation tube for different criterion functionals. The structure of an error of the method is described.

*Key Words:* monitoring, neutron flux, detection

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**Testing of Negative Flux Fixup Method in Solving of Problems with Using of Tetrahedral Meshes and Finite-Element LD-Scheme**

*A.A. Nikolaev,*

JSC OKB "GIDROPRESS", 21 Ordzhonikidze Str., Podolsk, Moscow Region, 142103

The results of testing the finite-element LD-scheme PMSNSYS-II with the negative flux fixup method in solving of real-world problems are presented.

*Key Words:*  $S_N$ -method, PMSNSYS-II, LDFEM, negative flux fixup.

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**Testing of PMSNSYS-II Code by Calculations of the Benchmark Experiment BFS-61-1 without Spatial Homogenization**

*A.N. Skobelev, A.A. Nikolaev,*

JSC OKB «GIDROPRESS», 21 Ordzhonikidze Str., Podolsk, Moscow Region, 142103

The paper presents the results of verification a new three-dimensional DSN-code PMSNSYS-II with the libraries of nuclear data of software package REACTOR-GP by the example of calculations of complicated heterogeneous configuration BFS-61-1 of benchmark-experiment MMF-006. The PMSNSYS-II code features made possible to reproduce and calculate the benchmark-experiment without spatial homogenization using limited computational resources. A final calculated multigroup value of effective neutron multiplication factor obtained by the solution extrapolation method is in agreement with the value calculated by the Monte-Carlo method and the benchmark-value with accuracy of not worse than 0,5 %  $\Delta k$ .

*Key words:*  $S_N$ -method, multigroup library, NP314/52, NP30/19, REACTOR-GP, PMSNSYS-II, BFS-61, PMSNSYS-II, benchmark-experiment, effective neutron multiplication factor

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**Experiments in Justification of Selection of Mixing Grids for Their Application in TVS-2M**

*E.A. Lisenkov,*

JSC OKB «GIDROPRESS», 21 Ordzhonikidze Str., Podolsk, Moscow Region, 142103

The paper deals with description of experimental facilities, experiment procedure, as well as presentation of the results of investigations of mass transfer processes, critical heat fluxes and hydraulic characteristics of TVS-2M with mixing grids (MGr). The experiments were performed in OKB "GIDROPRESS" at "coolant mixing in FA" test facility, "critical heat flux" test rig and "cold" and "hot" hydraulic test facilities. Based on the results of these investigations an effect of grids-intensifiers on the FA

mixing processes is studied, the values of critical heat flux increase and pressure loss coefficients with the usage of different MGRs are evaluated. Taking into account the recommendations made proceeding from the results of experiments the TVS-2M fuel assembly with mixing grids “Vikhr” and “Progonka” is designed and manufactured.

*Key words:* coolant mixing, critical heat flux, pressure losses, spacer grid, mixing grid, fuel assembly.

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### **Studies of Coolant Flow Non-Uniformities in FA with Mixing Grids**

*E.A. Lisenkov, D.V. Zaitsev, A.N. Churkin, A.V. Seleznev, S.A. Kushmanov, A.P. Skibin,  
A.A. Krutikov, Yu.A. Bezrukov,*

JSC OKB "GIDROPRESS", 21 Ordzhonikidze Str., Podolsk, Moscow Region, 142103;

*D.V. Malchevsky, S.E. Volkov,*

JSC “TVEL”, 49 Kashirskoe road, Moscow, 115409

The paper presents analysis of coolant flow non-uniformities over the cross-section of a fuel assembly with mixing grids and without a periphery row of subchannels. The paper gives the results related to commercial CFD code STAR-CD, as well as the experimental data obtained at an aerodynamic test bench using dummy TVS-2M with mixing grids “Vikhr” and “Progonka” and without them. The experiments were carried out in OKB “GIDROPRESS” using the optic measurement methods. Based on the results of the performed analysis an effect of MGR onto coolant flow distribution between the central part of a bundle and its periphery is evaluated.

*Keywords:* FA, spacer grid, mixing grid, coolant flowrate non-uniformity.

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### **Calculation-Based Study of Condensation-Induced Water Hammers in Reactor Plant Pipelines**

*A.N. Churkin, D.A. Posysaev, A.M. Baisov,*

JSC OKB "GIDROPRESS", 21 Ordzhonikidze Str., Podolsk, Moscow Region, 142103,

*N.A. Pribaturin, S.I. Lezhnin, M.V. Alexeev,*

Kutateladze Institute of Thermophysics SB RAS, 1 Academician Lavrentiev av., Novosibirsk, 630090

Calculation-based study for determination of a possibility for occurrence of condensation-induced water hammers at experimental models of pipelines is made to verify module SLUGGING in computer code KORSAR/GP. The calculation results are analyzed and compared with experimental data obtained at experimental facility “Gidroudar”. The operating parameter ranges, within which the occurrence of condensation-induced water hammers is possible, are determined. A significant difference in their intensity and frequency is established as compared with experimental data. Recommendations are proposed for improvement of computational module.

*Key words:* nuclear reactors, experimental facility, pipelines, condensate-induced water hammers, calculation-based study.

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### **CFD Modeling of an Experimental Section of 37-Rod Test Bench**

*V.Yu. Volkov, L.A. Golibrodo, A.A. Krutikov, O.V. Kudryavtsev, Yu.N. Nadinsky, A.P. Skibin,  
JSC OKB "GIDROPRESS", 21 Ordzhonikidze Str., Podolsk, Moscow Region, 142103.*

*D.A. Olexyuk, L.L. Kobzar,*

NRC “Kurchatov Institute”, 1 Kurchatov sq. 123182 Moscow.

The paper presents the results of CFD modeling of coolant flowing considering a conjugate heat transfer in a 37-rod fuel rod bundle of the KS test bench in NRC “Kurchatov Institute”. A base design version of

dummy FA – a bundle equipped with models of standard spacing grids of TVS-2M-type fuel assembly for WWER RP – is tested. Numerical analysis is carried out using software package STAR-CCM+. The results of CFD modeling are compared with the experimental data and the data obtained by cellular code SC-INT are subject to cross-verification. The results of CFD modeling can be used to obtain a series of approximating functions and constitutive correlations for cellular thermohydraulic codes.

*Key words:* fuel rod bundle, cross-verification, CFD, SC-INT.

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**Studies of the State of Absorbing Elements with a Combined Core and a Cladding Made of Alloy 42CrNiMo after Operation within 10 Years at Kalinin NPP**

*A.V. Zakharov, E.M. Muraliva, A.V. Strozhek, G.V. Shevlyakov,*

JSC «SSC RIAR», 9 Zapadnoe r. 433510 Dimitrovgrad, Ulyanovsk region,

*S.A. Kushmanov, K. Yu. Kurakin, V.M. Makhin, D.E. Zubtsov,*

JSC OKB "GIDROPRESS", 21 Ordzhonikidze Str., Podolsk, Moscow Region, 142103

The paper considers the results of post-reactor studies of rod cluster control assemblies (RCCA) of WWER-1000. Based on the results of performed studies of RCCA it is recommended to extend the assigned life for absorbing elements of the structure 2173.00.000 with a combined absorbing core up to 15 years, at least.

*Key words:* absorbing rod, control rod, reactor.

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**Water Chemistry Control and Water Treatment Plant of Units with WWER-1000**

*E.B. Yurchevsky,*

JSC OKB "GIDROPRESS", 21 Ordzhonikidze Str., Podolsk, Moscow Region, 142103,

*B.M. Larin,*

SEI HPE "Ivanovo State Power University named after V.I. Lenin", 34 Rabfakovskaya str. Ivanovo, 153003

The paper deals with consideration of a problem related to pH value measurement under the conditions of high purity of water coolant required for effective maintaining the secondary ethanolamine water chemistry at NPP with WWER-1000. It is shown that improvement of pH value measurement using the autoanalyzers under the conditions of superpure water coolant can be provided by two methods. The first method involves transition to an indirect measurement of pH value using the measurements of specific conductivity of cooled direct ( $\chi$ ) and H-cation ( $\chi_{\text{H}}$ ) samples of water. The second method provides for solution of mathematical formulation of ionic equilibriums of condensate sample in flow or feedwater flowing through the conductivity meters upstream of H-cation column ( $\chi$ ) and downstream of it ( $\chi_{\text{H}}$ ). It is also showed that guaranteed removal of the unionized impurities consisting of oxides of iron, silicon and aluminum in the form of complex compounds from water to be treated is ensured by means of application of the membrane technologies for water treatment.

*Key words:* water chemistry, ethanolamine water chemistry, coolant quality control, pH value measurement, ionic equilibriums, membrane technology of water treatment, molecular mass of organics.