

FEDERAL NUCLEAR ORGANIZATION  
Federal state unitary enterprise  
“Alexandrov Research Institute of Technology”

NUCLEAR PROPULSION  
REACTOR PLANTS.  
LIFE CYCLE MANAGEMENT  
TECHNOLOGIES

COLLECTION OF PAPERS

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# NUCLEAR PROPULSION REACTOR PLANTS. LIFE CYCLE MANAGEMENT TECHNOLOGIES

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## **Development of solution algorithms in the SAPFIR\_95&RC program package for calculation of neutronic characteristics of different reactors**

*V.G. Artemov, L.M. Artemova, A.S. Ivanov, A.S. Karpov, V.G. Korotayev, A.N. Kuznetsov*

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### **Abstract**

The paper presents ways for upgrading algorithms in the SAPFIR\_95 and RC programs of the SAPFIR\_95&RC package that is intended to calculate neutronic characteristics of reactors of different types including nuclear propulsion reactors and VVERs.

A module for calculation of burnup with an extended set of isotopes in the SAPFIR\_95 program, which calculates reactor sub-channel neutronic characteristics, is developed. A multi-group library of neutron constants based on Russia’s ROSFOND evaluated nuclear data files is prepared for a new version of the program that is named SAPFIR\_RF.

Algorithms for steady-state and transient solution of a multi-group (up to 26 groups) neutron diffusion equation are tested in the RC program that is designed to calculate neutronic characteristics of reactor cores.

The SAPFIR\_95&RC program package implements a 3D pinwise reactor calculation using the fuel burnup distribution obtained with the reconstruction method based on a macroscopic calculation of the neutron flux density in the reactor core and microscopic distributions in the fuel assemblies. The pinwise approach is tried out in calculations of both steady-state and transient problems. Transient simulations are performed by coupling the SAPFIR\_95&RC and the KORSAR thermal-hydraulic computer code.

A utility package is prepared, which enhances the SAPFIR\_95&RC capabilities regarding automation of input data preparation and processing of calculation results.

**Key words:** nuclear reactor, calculation of neutronic characteristics, computer program

## **Development, verification and application of the KORSAR/LMR computer code**

*S.N. Volkova, D.V. Benediktov, A.V. Vakarin, I.G. Danilov,  
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### **Abstract**

The advanced KORSAR/LMR code version is developed for safety assessment of new nuclear reactor designs with a liquid metal as a coolant.

The procedure for calculation of the thermal-hydraulic phenomena in the coolant circuits and system of closure relations is described. Examples of the code local verification and validation against experiment data from the KM-1 naval reactor prototype plant at FSUE “Alexandrov NITP” are given.

**Key words:** liquid metal cooled reactor system, KORSAR/LMR computer code, simulation model, verification, validation.

## **Influence of hydrazine decomposition kinetics on mass transfer of corrosion products in propulsion reactor primary coolant**

*A.V. Zhizhin, A.A. Zmitrodan, S.N. Orlov*

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### **Abstract**

The paper analyzes the effects of hydrazine decomposition in the primary coolant of a shutdown propulsion reactor. The decomposition reaction kinetics and inventory of the reaction products depend on the contributions of radiolytic and thermal decomposition mechanisms. Using experiment data, the rate of radiolytic hydrazine decomposition is determined to be within 10-20 mg/(L·h) and a function of core power. The contribution of thermolysis can amount to 25 % and higher percentage at coolant temperatures above 200 °C and whatever core power.

Experiments have shown that hydrazine addition increases release and mass transfer of corrosion products in the coolant, resulting in improved efficiency of corrosion product removal from the propulsion reactor primary system by ion exchange filters.

**Key words:** primary coolant, hydrazine, thermolysis, radiolysis, ammonia, hydrogen, nitrogen, hydrazine decomposition kinetics.

## Study of hydrogen release on heating steel samples protected by anti-corrosive coatings under realistic accident conditions

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### Abstract

The paper describes a procedure for studying release of hydrogen from heated steel samples protected by anti-corrosive coatings. Experimental studies were performed under different heating conditions and for different coatings of steels used as material in VVER-1200 containments. Tests were carried out on steel samples. The sample surfaces were preliminarily metallized with aluminum and coated with VINICOR EP-1155D and VINICOR EP-5285 epoxy enamels or pretreated with ZINEP zinc-rich primer and coated with VINICOR EP-1155D and VINICOR EP-5285 epoxy enamels.

The tests have shown release of hydrogen from the steel samples being heated in simulated accident environment, therefore demonstrating that application of VINICOR EP-1155D and VINICOR EP-5285 anti-corrosive coatings on steel surfaces pretreated by means of thermal metallization with aluminum or ZINEP zinc-rich primer does not comply with applicable Russia’s federal nuclear regulations.

Analysis of the test results indicates that hydrogen release from the heated steel samples is essentially caused by pretreatment of steel surfaces by means of either thermal metallization with aluminum or application of zinc-rich primer.

**Key words:** hydrogen, protective coatings, containment, reactor, severe accident.

## **Analysis of Possibility for Automated Assessment of VVER Steam Generator Leak Rate Using ARMS Measurements**

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### **Abstract**

The Leningrad NPP-2 and the Tianwan NPP (China) projects are used as an example to discuss the efficiency of radiation monitoring methods for early detection and assessment of primary-to-secondary leakage through VVER steam generators, based on the automated radiation monitoring system measurements.

Factors are considered that affect the correctness of the primary-to-secondary leak rate assessment. The assessment is obtained using measurements of  $^{16}\text{N}$  dose rate from the main steam line, activity of reference radionuclides in the blowdown water, activity of steam-gas flow at the ejector exhaust, and dose rate from the steam generator blowdown water cleanup filters.

The prospects of using Russia’s newly developed equipment (spectrometric monitors) for early detection and assessment of the primary coolant leak rate in VVER NPPs are discussed.

**Key words:** automated radiation monitoring system, VVER, primary coolant, steam generator, volumetric radionuclide activity, radioactive inert gases, leak monitoring, detection equipment.



## On regulatory control of ventilation systems important to safety of nuclear power plants

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### Abstract

This article presents an analysis of the national regulatory system of ventilation systems important to safety, nuclear power plants, as well as international approaches used in the design and operation of the above-mentioned systems. Based on the results of the analysis performed, this article proposes the main directions for improving federal rules and regulations «Rules for the design and operation of Ventilation systems important to safety of nuclear plants» (NP-036-05). The proposed directions for improving the requirements of NP-036-05 with their planned revision will increase the efficiency of regulatory control of ventilation systems important to safety nuclear power plants, as well as their safety and competitiveness.

**Key words:** nuclear power plants, ventilation systems, iodine and aerosol filters, design, installation and operation.