

Abstracts

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The History of RFNC-VNIIEF Nuclear Pulse Reactors Creation and Progress

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Pulse nuclear reactors (PNR) have been in operation at VNIIEF more than 50 years. Reactor VIR-1 with solution core and reactor BIR-1 with metal core were first PNR. Now 5 PNR VIR-2M, BIGR, BR-1M, BR-K1, and GIR2 are in operation at VNIIEF. Know-how, technical innovation of PNR and designing of new installations guarantee accident free operation of unique PNR and multifarious scientific researches realization.

Key words: pulse nuclear reactor, development of pulse reactors, designs of pulse reactors, nuclear radiation parameters, safety problems.

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Reactor BIGR

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The given review paper is devoted to BIGR reactor developed at VNIIEF in the year of 1977. The aim of its development is contemplated. There are highlighted basic lines of research activities performed on the facility. The report is supplemented by a brief description of the reactor neutron-physics parameters and the characteristic shapes of fission pulses generated on the reactor are presented. Described are possible sites for irradiation objects mounting as well as devices applied for reactor irradiation feasibility. Reported is data summary on the reactor employment for the moment of the current document preparation.

Key words: reactor BIGR, fission pulse shape, pulse mode, quasi-pulse mode, static mode.

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Aperiodic Pulsed Reactors GIR and GIR-2

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The description of aperiodic pulsed reactors GIR and GIR-2 developed in VNIIEF and included to irradiation complexes LIA-10 – GIR and LIA-10M – GIR-2 is given. The brief information on the configuration of reactor cores as well as the overall view of reactors and the arrangement of reactor-based complexes are presented. General results of the researches carried out on LIA-10 – GIR and LIA-10M – GIR-2 are stated.

Key words: aperiodic pulsed reactor, reactor core, reactor gamma-ray source, irradiation complex, (n, γ)-converter.

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Ways of Modernisation of BR-K1 for Enabling of Operation in Pulse Mode

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The works devoted to modernization of BR-K1 pulse reactor are given in this article. The existing design of reactor and problems interfering with its operation in pulse mode are described in the first part. The ways of the above problems solution are described in the following parts: replacement of steel cases with those of titanium alloy to reduce stress and deformation, installation of neutron reflector to reduce stresses in reactor core through increasing pulse duration, installation of new fast pulse unit to reduce shock loads and enable pulse generation under constant power mode.

Key words: booster-reactor, modernization, steel case, titanium alloy, stress, deformation, reflector, fast pulse unit.

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The Second-Generation Fissile Materials in Nuclear Power Industry

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The paper shows that the use of ^{232}Th for a raw isotope instead of ^{238}U and the main fissile isotope ^{233}U instead of ^{239}Pu , the use of heavy water instead of light water as a coolant and its dilution with light water during the VVER-type reactor campaign provide the self-reproduction of active isotopes in fuel, particularly upon the achieved equilibrium ratio of actinide isotopes, improves safety of a reactor, and provides a technological barrier against the distribution of fissile materials. The effective utilization of highlyenriched uranium (HEU) takes place in stage of reaching the closed thorium-uranium-plutonium fuel cycle with deep transmutation of actinides by fission reaction and their removal from radioactive waste.

Key words: ^{232}Th and ^{233}U isotopes of the second generation; HEU utilization; self-production of active isotopes in fuel; closed thorium-uranium-plutonium fuel cycle; transmutation of actinides by fission reaction.

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Neutron-Physical Experiments at Pulsed Reactors BIR-2M and BIGR

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In the course of their long-term operation BIR and BIGR reactors, besides their primary function (generation of n - γ irradiation pulses for irradiation purposes), were regularly used for performing experiments, which were aimed at studying the possibility of improvement of pulsed reactor n - γ irradiation parameters, at increasing their nuclear safety, as well as at studying neutron physics issues. The present review considers the following issues: long-term behavior of BIR and BIGR reactors in the mode of power self-regulation; generation of pulse while the rod is passing though the core of the reactors; coupled systems: (BIR reactor subcritical assembly); experiments with ultracold neutrons at BIGR reactor; fast-response scram system and fission pulse delay time in BIR reactor in case of weak neutron source in the core.

Key words: experiments on pulse reactors, reactor BIR-2M, reactor BIGR, parameters of reactor radiation, nuclear safety, reactor self-regulation, pulsed rod pass-through, coupled reactors.

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Optical Materials and Fibers in Experiments on Pulsed Nuclear Reactors

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Review of methods relating to radiation-resistance investigations of optical materials and fibers on pulse nuclear reactors is presented.

Key words: optical materials, optical fibers, reactor irradiation, induced absorption.

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***Actuating Mechanism of Reactor Safety System with Independent Energy Source
on The Base of Pyrotechnic Gas Generator***

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There is described the design of actuating mechanism with independent energy source on the base of pyrotechnic gas generator aimed at chain nuclear reaction termination at abnormal reactor operation. There are considered the peculiarities of gas generator design as well as gas-generating pyrotechnic compositions on the base of sodium azide. There are presented the results of independent energy source models testing and the experimental data on studying the model of safety system actuating mechanism with gas generator. The algorithm and calculation model of gas generator consumption characteristic determination is proposed. The calculations of the actuating mechanism dynamic characteristics are performed. The results testify to the fact that pyrotechnic gas generator can be used as efficient energy source in the actuating mechanism of the nuclear reactor safety system.

Key words: nuclear reactor, safety system, pneumatic actuating mechanism, pyrotechnic composition, pyrotechnic gas generator.

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Multifunction Measuring Device Used on Pulsed Nuclear Reactors

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Brief information is presented on the necessity and possibility of using flexibly tunable multifunctional measuring intellectual device of the first and second generation – UIMI and UIMI2 – on the base of National Instruments modules. Measurement, triggering and auxiliary channels making it possible to register signals both in manual and automated modes in a wide time and amplitude signal range are realized in terms of operation modes of pulsed nuclear reactors.

Key words: pulsed nuclear reactor, reactor measuring system, reactor measuring modules, registration of signals, user interface.

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A Combined Hardware-Software System of Channels for Power Control of Research Nuclear Facilities

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The unitized hardware-software system of channels for power control of research nuclear facilities (HSS PCC) is a combination of hardware and software environment where the algorithms of physical characteristics control of research nuclear facilities (RNF), monitoring signal generation, data processing are implemented. The real time monitoring of nuclear facility physical power and the rate (period) of its variation through reading by neutron detectors of different type with various spectral sensitive gas-filled counter tubes and current fission chambers make the HSS PCC a full-scale means of RNF operation control. In 2014 there was completed in the INRP the development of HSS PCC aimed at measuring physical power and rate of its variation at RNF (research nuclear reactors, critical and sub-critical test-beds) in the modes from fully damped state to the nominal level of their power. The hardware-software system of PCC is included in the RNF protection and control system; it broadens functional possibilities of the system of protection and control and improves reliability of RNF operation as a whole. The range of physical power control is ($10^{-5} \dots 10^6$) W, while the range of power variation period control is (1 – 200) sec.

Key words: research nuclear facility, hardware-software system, protection and control system, measuring channel, nuclear facility physical power, rate (period) of power variation, control software.

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Intensity Distribution Measurement for a Source of Hard X-Rays

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The procedure of measuring brightness distribution of betatron MIB-7,5 hard X-ray source fulfilled with the aid of penumbral imaging technique is described (algorithm and calculated model are proposed). This method is based on the possibility of reconstructing brightness of a source of penetrating radiation encoded in a uniformly bright region surrounded by a penumbra of a large circular collimator (hedged region). The estimation of influence of penumbral aperture diameter on the value of signal-noise ratio in the distribution of the source brightness is given in the paper. The parametric model of the source X-ray pattern formation is presented. The parametric model involves a priori information on measurements setting and brightness distribution of the radiation source.

Key words: X-ray radiography, radiography, penumbral aperture, X-ray source, point spread function, parametric model of measurements, betatron.