

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

NUCLEAR PROPULSION
REACTOR PLANTS.
LIFE CYCLE MANAGEMENT
TECHNOLOGIES

COLLECTION OF PAPERS

№ 4 (22) 2020

Sosnovy Bor
2020

NUCLEAR PROPULSION REACTOR PLANTS. LIFE CYCLE MANAGEMENT TECHNOLOGIES

Collection of papers. Periodical edition

№ 4 (22) 2020

Published since 2015

The edition is distributed in the Russian Federation

EDITORIAL BOARD

Editor-in-Chief V. A. Vasilenko, Professor, Dr.Sc. (Engineering), Director General of Alexandrov Research Institute of Technology, Sosnovy Bor.

MEMBERS OF THE EDITORIAL BOARD

- V.R. Axenov,** Publication Editor, Cand. Sc. (Engineering), Alexandrov Research Institute of Technology, Sosnovy Bor.
- V.I. Almjashev,** Cand. Sc. (Chemistry), Alexandrov Research Institute of Technology, Sosnovy Bor.
- A.Ya. Blagoveshchensky,** Dr. Sc. (Engineering), Professor, Naval Polytechnic Institute of the Naval Academy (Military Educational and Research Center) in Saint Petersburg.
- V.I. Bursuk,** Dr. Sc. (Engineering), Director of the Service Center, JSC Concern Aurora SPA, Saint Petersburg.
- V.S. Gursky,** Dr. Sc. (Engineering), Alexandrov Research Institute of Technology, Sosnovy Bor.
- A.L. Dmitriev,** Alexandrov Research Institute of Technology, Sosnovy Bor.
- A.V. Elshin,** Dr. Sc. (Engineering), Alexandrov Research Institute of Technology, Sosnovy Bor.
- A.A. Efimov,** Dr. Sc. (Chemistry), Alexandrov Research Institute of Technology, Sosnovy Bor.
- V. N. Zimakov,** Dr. Sc. (Engineering), Alexandrov Research Institute of Technology, Sosnovy Bor.
- Yu.V. Kriukov,** Assistant Editor, Cand. Sc. (Engineering), Alexandrov Research Institute of Technology, Sosnovy Bor.
- Yu.A. Migrov,** Dr. Sc. (Engineering), Alexandrov Research Institute of Technology, Sosnovy Bor.
- L.N. Moskvin,** Dr. Sc. (Chemistry), Saint Petersburg State University.
- E.B. Pankina,** Cand. Sc. (Engineering), Alexandrov Research Institute of Technology, Sosnovy Bor.
- S.A. Petrov,** Dr. Sc. (Engineering), Research Institute of Navy Shipbuilding and Armaments, Saint Petersburg.
- O.Yu. Pyhteyev,** Cand. Sc. (Chemistry), Alexandrov Research Institute of Technology, Sosnovy Bor.
- O.B. Samoilov,** Dr. Sc. (Engineering), JSC Afrikantov OKBM, Nizhny Novgorod.
- V.B. Khabensky,** Dr. Sc. (Engineering), Alexandrov Research Institute of Technology, Sosnovy Bor.

FOUNDER:

Federal nuclear organization. Federal state unitary enterprise «Alexandrov Research Institute of Technology».

PUBLICATION IS REGISTERED:

Federal service of supervision for communications. Registration certificate ПИИ No. ФС77–58865, 28.07.14.

EDITORIAL OFFICE ADDRESS:

FNO FSUE «Alexandrov NITI», 72 Koporskoye shosse, Sosnovy Bor, Leningrad region, 188540 Russia
Tel.: 8 (813 69) 6 01 43 — Executive Secretary of Editorial Board.
Fax: 8 (813 69) 2 36 72. E-mail: foton@niti.ru; Website: www.niti.ru.

Subscription number in the «Russian Press» aggregate catalogue is 43300.

This Collection of Papers is included in the List of peer-reviewed scientific editions accredited for publishing results of doctoral and candidate degree thesis studies in discipline 05.14.03 — Nuclear power installations: design, operation, and decommissioning (engineering sciences).

Copyright notice: Reproduction of this edition in whole or in part shall always include the words “Reprinted from Collection of Papers «Nuclear propulsion reactor plants. Life cycle management technologies»”.

Contents

Issue № 4 (22) 2020

Modeling and research of neutron and thermal-physical processes in propulsion reactor plants

A.V. Elshin

A numerical investigation in the behavior of coolant flow radially injected
Boundary conditions in surface harmonics method 14

Yu.V. Yudov, S.N. Rummyantsev, S.S. Chepilko

KORSAR/CFD calculations of coolant mixing processes with different number
of pumps in operation in the VVER-1000 reactor model
at the four-loop test facility of OKB "GIDROPRESS" 26

Use of chemical technologies in propulsion reactor plant life cycle management, radiochemical
and material research

A.M. Alyoshin, A.A. Afanasyev, A.A. Zmitrodan

Decommissioning of experimental installations used to test technologies for radwaste
management at naval reactor facilities 42

Environmental impact of nuclear facilities

V.A. Erzova, K.B. Rozov, V.G. Rumynin

Thermal impact of nuclear power plants on changes in microclimate parameters 55

Research of severe accidents in nuclear

V.I. Almjashv, V.B. Khabensky, E.V. Krushinov, S.A. Vitol, A.A. Sulatsky, E.V. Shevchenko

Studies carried out at the "Rasplav" platform of severe accidents research department
of FSUE Alexandrov NITI 69

UDC 621.039.51

Boundary conditions in surface harmonics method

A.V. Elshin^{1, 2}

¹ FSUE “Alexandrov NITI”, Sosnovy Bor, Leningrad region, Russia;

² Peter the Great St. Petersburg Polytechnic University, Russia

Abstract

Mark and Marshak type vacuum boundary conditions are applied at the reactor boundary when computing the space-energy distribution of neutrons with the diffusion or higher approximations for neutron transport equations (e.g. using the surface harmonics method) in reactor neutron calculations. This paper compares application of these conditions to solution of a test one-group, one-dimensional problem using the spherical harmonics method (with up to P_{97} -approximations) and surface harmonics method with different approximations.

Key words: Surface harmonics method, spherical harmonics method, vacuum boundary conditions, Mark type conditions, Marshak type conditions, test problem.

UDC УДК 532.542: 004.942

KORSAR/CFD calculations of coolant mixing processes with different number of pumps in operation in the VVER-1000 reactor model at the four-loop test facility of OKB "GIDROPRESS"

Yu.V. Yudov, S.N. Rummyantsev, S.S. Chepilko

FSUE "Alexandrov NITI", Sosnovy Bor, Leningrad region, Russia

Abstract

This paper compares the results of KORSAR/CFD calculations with data from the second series experiments carried out in the VVER-1000 reactor model at the four-loop test facility of OKB "GIDROPRESS". The experiments simulated the mixing phenomena in the reactor lower plenum under conditions of temperature or boron concentration disturbance in one of the loops with different number of coolant pumps in operation. Significant sensitivity of the calculation results to slight variations in the conditions of coolant flow from the inlet nozzles (change of nozzle inclination angle by 3°) is observed. The effect of the coolant flow pattern in the annular region on the boron concentration distribution at the core inlet is shown.

Key words: reactor, lower plenum, coolant, concentration, experiment, computer code, computational grid, computational fluid dynamics.

UDC 621.039.74/75

Decommissioning of experimental installations used to test technologies for radwaste management at naval reactor facilities

A.M. Alyoshin, A.A. Afanasyev, A.A. Zmitrodan

FSUE “Alexandrov NITI”, Sosnovy Bor, Leningrad region, Russia

Abstract

The paper presents methodological, engineering, and technological approaches to decommissioning of hazardous radiation facilities on an example of final closure of experimental installations intended for testing radwaste management technologies applicable at naval reactor facilities. Decommissioning project documentation, necessary equipment, methods and procedures, scope of dismantling and decontamination work, nomenclature and quantitative characteristics of radioactive and non-radioactive industrial wastes, and waste management capabilities are described. Prospects for transferring the generated waste to the national operator for final disposal are discussed. Equipment components that have to be disassembled and taken out of service are characterized. Organizational measures for preparing and conducting large-scale work are mentioned.

Key words: experimental installations, decommissioning, hazardous radiation facility, radioactive contamination, decontamination, decontamination solutions, radioactive waste, equipment.

UDC 502.3

Thermal impact of nuclear power plants on changes in microclimate parameters

V.A. Erzova^{1,2}, K.B. Rozov^{2,3}, V.G. Rumynin^{2,3}

¹Saint-Petersburg mining university, Russia;

²Saint-Petersburg Division of Sergeev Institute of Environmental Geology of the Russian Academy of Sciences, Russia;

³Saint-Petersburg State University, Institute of Earth Sciences, Russia

Abstract

Cooling towers are designed to cool the process equipment of the nuclear power plant (NPP) and to remove excess heat from the reactor. However, this approach may have a negative impact on the environment. The environmental impact of cooling towers is therefore assessed during the design and construction of nuclear power plants. This article provides predictive modeling results of the impact of cooling towers using the SACTI2 software package for the Uzbek NPP. Predictions of the occurrence of air-vapor plume, shading of the territory, absorption of total solar energy by the air-vapor plume, precipitation and salt deposition on the surrounding area are provided in this work.

Key words: cooling system, cooling tower, nuclear power plant, SACTI2 software, impact on microclimate, air-vapor release.

UDC 621.039.586

Studies carried out at the “Rasplav” platform of severe accidents research department of FSUE Alexandrov NITI

^{1,2}*V.I. Almjashev, ¹V.B. Khabensky, ¹E.V. Krushinov, ¹S.A. Vitol,
¹A.A. Sulatsky, ¹E.V. Shevchenko*

¹Alexandrov Research Institute of Technology (NITI), Sosnovy Bor, Leningrad region, Russia;

²Saint Petersburg State Electrotechnical University “LETI”, Saint Petersburg, Russia

Abstract

The article provides an overview of the directions and results of experimental work in the field of research of severe accidents carried out at the set of experimental facilities “Rasplav” at Alexandrov NITI. The results of the work carried out are widely used to substantiate safety systems for nuclear power plants, improve the accuracy of predicting severe accident scenarios at nuclear power plants, in the development and substantiation of the functioning of new materials for nuclear power in extreme conditions.

Key words: severe accidents, corium, NPP safety, set of experimental facilities “Rasplav” (“Rasplav” platform), induction melting in a cold crucible (IMCC).