# ANALYSIS OF THE PROCESS OF VERIFICATION AND ATTESTATION OF COMPUTER PROGRAMS USED FOR RESEARCH REACTOR CALCULATIONS IN THE RUSSIAN FEDERATION

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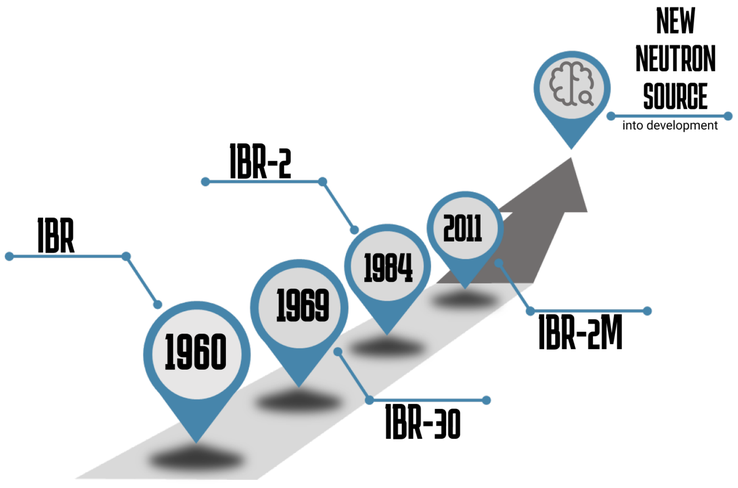
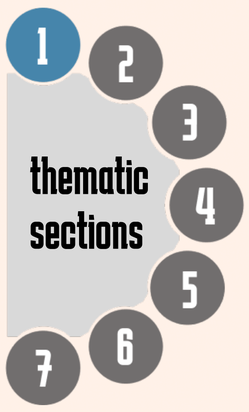



fig. 1 development history of pulse reactors in Dubna

## objective

The purpose of this study is to investigate the process of attestation of software programs. In addition, it is required to analyze the software programs in order to select the most appropriate programs and to perform their validation and verification by writing a report.

Programs for safety justification calculations can be divided into seven groups depending on the purpose of the calculation. Based on these groups, seven thematic sections have been created, each of which is responsible for the certification of programs for its own specialized area of calculations. **Fig. 2** lists the sections, as well as examples of program sets certified within each section. It should be noted that in this work, the software programs belonging to the first thematic section are analyzed.




1 - Neutron physics calculations **(Serpent, MCNP, TDMCC...)**
2 - Calculations of heat transfer and hydrodynamics, related neutron physics and thermohydraulic calculations, modeling of non-stationary and emergency processes **(Athlet, SOCRAT-BN, CMS...)**
3 - Calculations of radiation protection and radiation safety **(Nostradamus, CARE_03,Alpha-M...)**
4 - Calculations of the stress-strain state and analysis of the strength of the elements of the reactor core, equipment and pipelines of NPPs **(FRACAL2, Ansys - Mechanical, DINARA...)**
5 - Probabilistic security analysis. Reliability analysis of process control and management systems **(SCAD, AvroRel v.3.0, ...)**
6 - Calculations of building structures of NPPs and their reactions to external influences **(FRACAL2, Ansys - Mechanical, DINARA...)**
7 - Computational modeling of physico-chemical processes affecting the nuclear and radiation safety of NPPs **(Ecolego,Gera, ...)**

fig. 2 attestation thematic sections

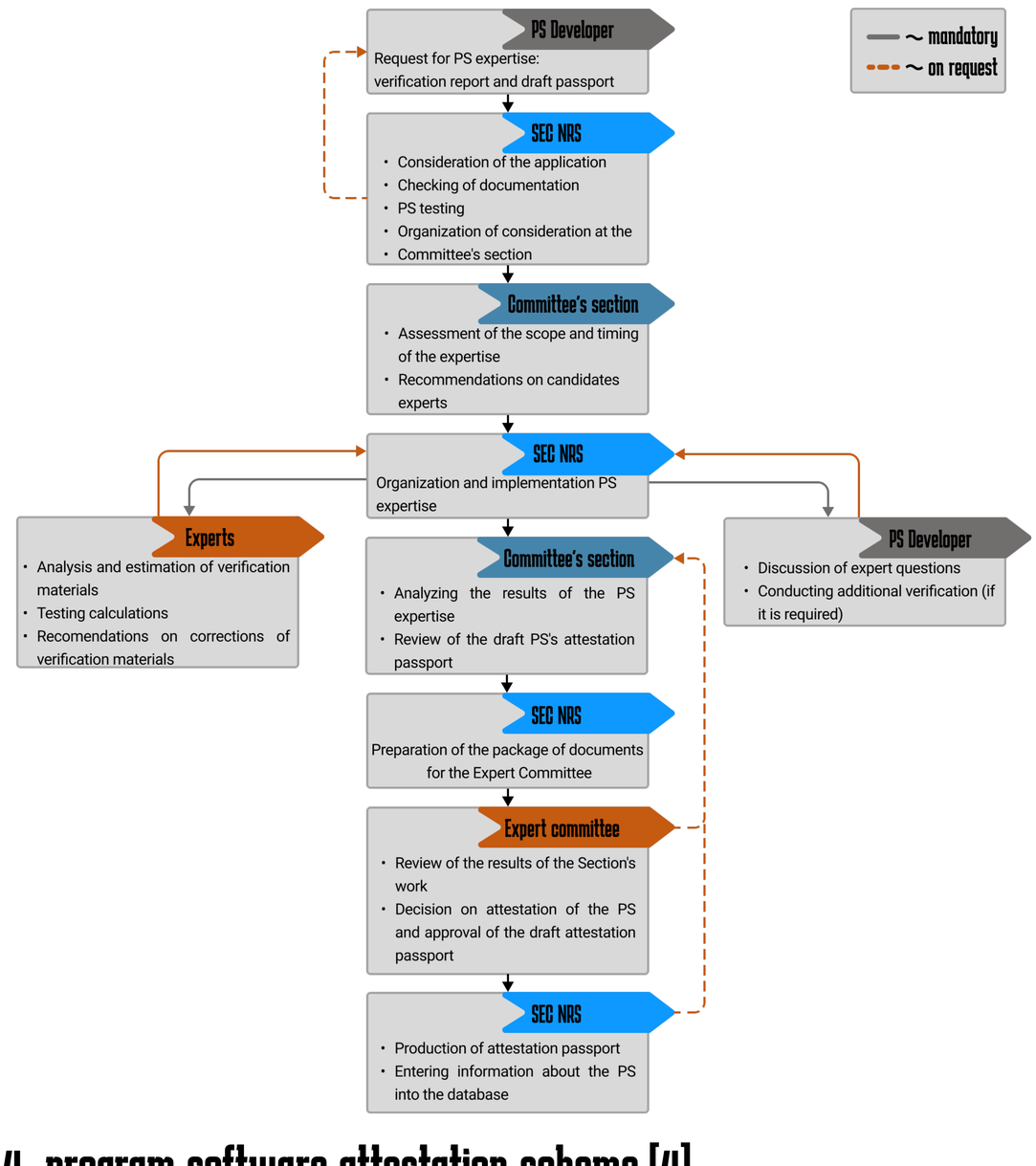



fig. 4 program software attestation scheme [4]

## conclusion

In the context of constantly changing technological and safety requirements in the field of nuclear power, the need for early attestation of a number of software programs, as well as making additions to already attested PS in the Attestation Passport, is an extremely important and urgent task. Attestation of PS plays an important role in ensuring the safety of nuclear facilities, as it helps to ensure their reliable and efficient operation in accordance with modern standards and requirements.

## references

**[1]** The requirements for the content of the report on safety justification of research nuclear facilities (NP-049-17) - The Federal Service for Environmental, Technological and Nuclear Supervision, Moscow, 2018 [*in Russian*].
**[2]** Federal Law No. 170-FZ of November 21, 1995, "On the Use of Atomic Energy". base.garant.ru, 22-01-2024, URL: https://base.garant.ru/510105506/
**[3]** Bogdan S. N., Zhylmaganbetov N. M., Kozlova N. A., Ponizov A. V., Sharafutdinov R. B., Shevchenko R. A., Shevchenko S. A., Yashnikov D. A. Current issues of review of computer codes used for safety analysis of nuclear facilities. Nuclear and Radiation Safety, 2022, no. 2 (**104**), pp. 31–49. DOI: 10.26277/SECNRS.2022.104.2.002 [in Russian].
**[4]** Bogdan S.N., Kovalevich O.M., Hamaza A.A., Shevchenko S.A. Shevchenko S.A., STATUS AND DEVELOPMENT OF THE SYSTEM OF SOFTWARE ATTESTATION. Council for attestation of software programs at Rostechnadzor. 25 years at the service of safety // Collection of publications/ Proceedings of SEC NRS, 2016 - pp.11-21 [*in Russian*].
**[5]** SEC NRS. "List of Attestation Certificate of computer programs (as of 09.11.2023)". www.secnrs.ru, 18-01-2024, URL: https://www.secnrs.ru/expertise/software-review/ [*in Russian*].

## introduction

Currently, the Joint Institute for Nuclear Research is developing a new neutron source - the NEPTUNE fast pulsed reactor (see **fig. 1**), as the IBR-2 reactor will be exhausted by 2032. Therefore, it is extremely necessary to make calculations for the design and construction of the new facility. For the correct operation of the facility and the justification of its safety, a large number of calculations are required both by methodologies and by various software programs.

According to the requirements for the content of the report on safety justification of research nuclear facilities (NP-049-17 p.16) [**1**], the programs used must be verified and attested. Since May 23, 2018, amendments to Article 26 of Federal Law No. 170-FZ of November 21, 1995, "On the Use of Atomic Energy" [**2**], have stipulated that the development of calculation models must exclusively rely on software programs (SPs) that have undergone thorough expertise.

Creating calculation models using computer programs has its own limitations in applicability. The validity of such models in the Russian Federation is carried out by the Scientific and Engineering Centre for Nuclear and Radiation Safety (SEC NRS), which since 2018 is an official scientific and technical support organization of Rostechnadzor and carries out expert expertise of computer programs [**3**].

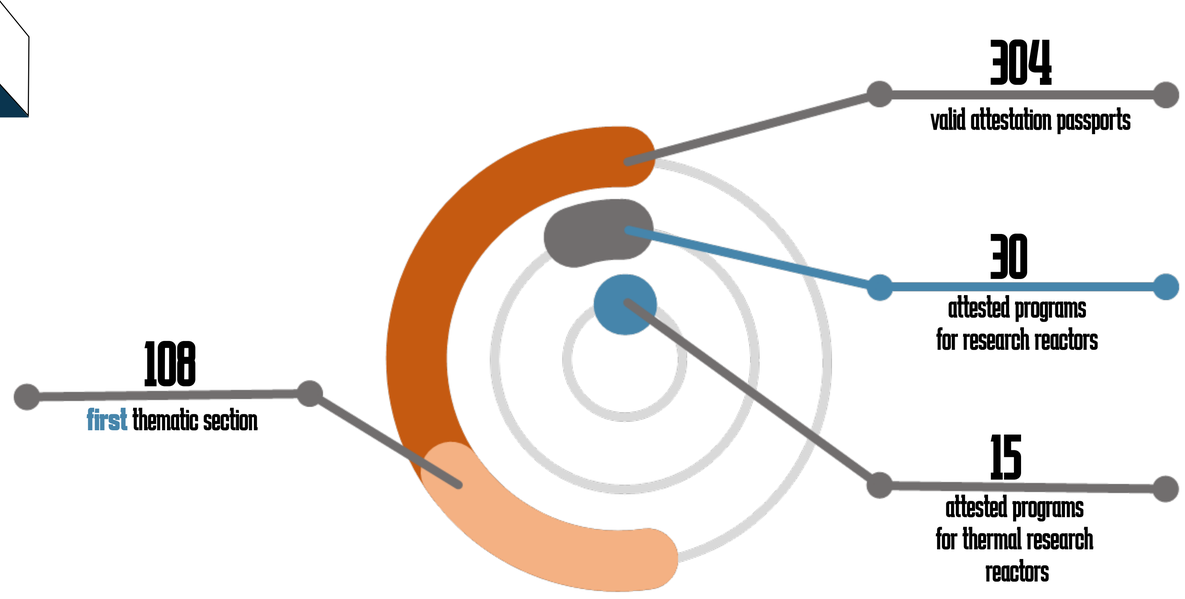



fig. 3 ratio chart of program software for 2023

## analysis & results

**Fig. 3** illustrates the present status of attested programs in the Russian Federation at the end of 2023. Out of the total 588 programs attested over the past two decades, only 304 hold valid attestation passports at the end of 2023, indicating a significant attrition rate due to the requirement for recertification every 10 years.

**Fig. 4** depicts the conventional scheme for attestation of computer programs, highlighting the process's complexity and implying that attestation might consume a considerable amount of time.

Unfortunately, most of the attested programs were attested for industrial nuclear installations (VVER and RBMK reactors). There are a number of reasons that complicate the attestation of PS for nuclear research reactors (NNR):

- NRRs characterization specificity:

NRRs have unique characteristics and parameters that do not always correspond to standard models and methodologies accepted for industrial reactor calculations. This requires the development of specialized software programs, their adaptation and verification for specific conditions of a particular NRR.

- Experimental data scarcity:

In a number of cases, insufficient experimental data on NRR operation and behavior can make it difficult to develop and verify software programs. Insufficient data can complicate the correct modeling of processes occurring in the reactor facility and lead to a decrease in the accuracy of calculations.

- Increased NRRs safety requirements:

NRRs are generally subjected to more stringent safety requirements, due in part to the experiments conducted at these facilities.

Moreover, the new requirement for verification and validation of PS introduce additional difficulties during attestation of programs. The essence of the requirement is that the experimental data for verification must be for the same installation for which attestation is performed. This requirement is difficult for installations that are presented in a single unit.

As a result of analyzing the different PSs (see Figure 5), two PSs were selected for further work: OpenMC and MCU.

Reasons for selection:

OpenMC is a powerful Monte Carlo code for simulating neutron transport. Here are some reasons why OpenMC can be considered a "user-friendly" program:

- Open Source
- Flexibility and scalability
- High accuracy and reliability
- Support for a wide range of tasks
- Active community of users and developers
- Integration with other software programs

Many of the above-mentioned advantages can be attributed to MCU. Regarding MCU it can be noted that this program complex is a domestic development and various modifications of this complex have successfully passed the attestation procedure several times.

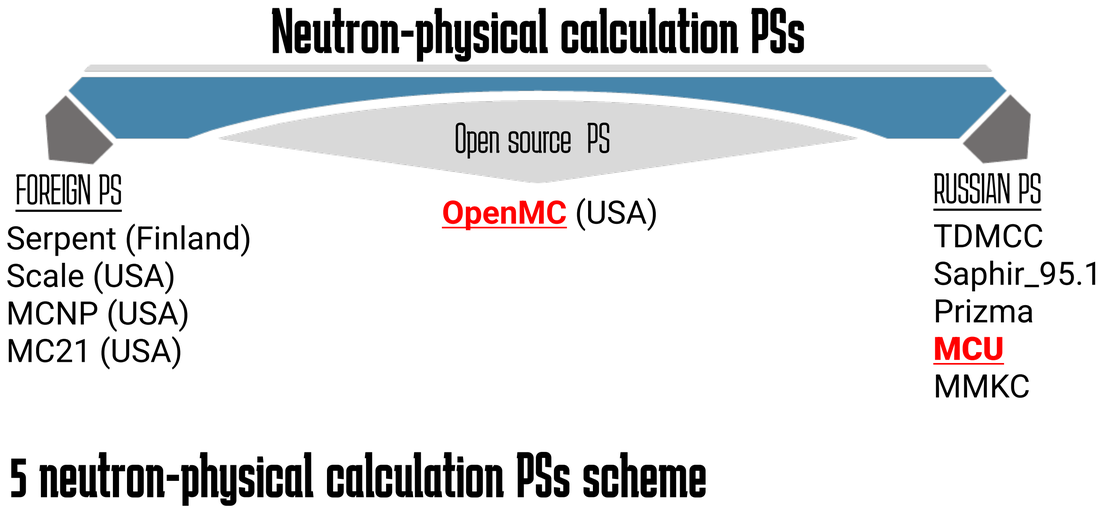



fig. 5 neutron-physical calculation PSs scheme