REVIEW REPORT

on the competition for academic position "Associate Professor"

Professional field: 4.1 Physics Sciences (Probabilistic Analysis in Nuclear Technologies), Faculty of Physics, Sofia University "St. Kliment Ohridski" promulgated in State Gazette No. 48 of 28.06.2022

The review report was prepared by Prof. Kiril Assenov Krezhov, Institute for Nuclear Research and Nuclear Energy (INRNE) - BAS, in his capacity as a member of the Scientific Jury in according to Order No. RD 38-449/ 25.07.2022. of the Rector of Sofia University.

A single candidate Dr. Georgi Ivanov Petkov, Kozloduy NPP, has submitted documents to occupy the announced academic position.

I. General description of the submitted materials

1. Applications details

The documents submitted by the candidate for the call comply with the Bulgarian national requirements and rules for acquiring scientific degrees Development of Academic Staff in the Republic of Bulgaria Act (DASRBA) and in the Regulations for its implementation (RIDASRBA), and the Regulations on the terms and conditions for acquiring scientific degrees and holding academic positions at Sofia University "St. Kliment Ohridski "(PURPNSZADSU).

For participation in the competition, the candidate Dr. G. I. Petkov submitted a list and copies of a total of **45** scientific works co-authored by him, mostly publications in materials of prestigious specialized scientific forums, including **37** works in foreign scientific editions, indexed in the "Scopus" and "Web of Science" databases.

The documents submitted for the competition give a sufficiently clear idea of the activity and professional development of the applicant. Presented are the diplomas for higher education and for the doctoral degree (candidate of technical sciences), the certificate for the title of Associate Professor (awarded by the VAK at the MS), lists and copies of publications, references for citations, author's reference for contributions, etc. A detailed CV of the candidate is presented, supported by an official note from TU-Sofia and copies of pages from a Bulgarian book of employment record, proving that during his almost 33 years of work as of the date of submission of the competition documents, he has gained extensive experience as a lecturer at TU - Sofia in the position of "Chief Assistant" (10 years and 6 months) and "Associate Professor" (8 years).

2. Details for the candidate

The candidate Georgi I. Petkov was born in 1960 in the town of Plovdiv. He received a diploma of higher education in 1986 from the Moscow Energy Institute (MEI, USSR) with the qualification degree "Engineer-thermal physicist" in the specialty "Nuclear power plants and devices" with a diploma thesis defended with honours on the topic "ATS-200 with natural circulation of the heat carrier", which is in the field of using a nuclear reactor in a heating plant. By decision of the Ministry of Education and Culture, the document was equated for education in the specialty "Nuclear energy and thermal energy" at TU-Sofia. In the period of November 1988 - June 1992, the applicant was a full-time doctoral student at MEI in Moscow and after defending a dissertation on the topic "Development of techniques and algorithms for modelling and analysis of the reliability of NPP systems" obtained the scientific degree "candidate of technical sciences" with a diploma dated June 19, 1992, recognized by a decision dated May 31, 1993 of the Higher Attestation Commission under the Council of Ministers of Bulgaria.

I believe that his postdoctoral training at the University of Tokyo and his visits as a guest scientist at TU-Lisbon (2000-2001) and Tokyo National University of Marine Research (2002) helped to enhance the applicant's qualifications early in his professional career and to diversify the scope of application of his knowledge and skills in the field of probabilistic safety analysis.

Georgi Petkov's professional work began after graduating from higher education in 1986 with his appointment as a senior engineer operator at Kozloduy NPP. After the commissioning in 1987 of the 5th unit (reactor VVER-1000, model B-320) and the completion of the doctoral studies in Moscow, in 1992 the applicant started working at the company Risk Engineering OOD, where he participated in the development and application of methods for probabilistic analysis of nuclear safety - level 1. In 1994, he was elected as a "Chief Assistant" in the College of Nuclear Energy at TU-Sofia, and in 1995 - as an "Associate Professor" of the Department of "Thermal Energy and Nuclear Energy" of TU, where he worked until 2014.

The accumulated experience and demonstrated specific knowledge of the candidate open opportunities for responsible analytical positions as a safety expert abroad and the applicant has worked in the Netherlands (at the EC Institute of Energy and Transport in Peten) and Finland (emergency procedures and other analyses on the Olkiluoto NPP Project 3.). In July 2020, he returned to the Kozloduy NPP, EP-2, in the position of Chief Expert "Probabilistic Safety Analysis" with tasks to "maintain and support the safety of units 5 and 6 when taking and implementing risk-informed solutions for modelling, monitoring, reliability and risk assessments, and analyses, and ensuring data and model adequacy for probabilistic safety analysis levels 1 and 2."

3. General characteristics of the scientific works and achievements of the candidate

Doctor G.I. Petkov has submitted a list (Complete List) of **101** titles of works published in a period of 31 years (1991-July 2022). In **44** of them, he is the sole author, incl. of the textbook "Radiation Protection" (120 p., TU-Sofia, 2004). The Scopus reference gives **104** citations to **32** applicant's papers. Generally speaking, these works address current problems in developing methods for

modelling, investigation, evaluation, and analysis of reliability and risk in steady-state and transient regimes of complex systems, as well as for considering the human factor in decision-making, under normal and emergency conditions of the NPP.

For participation in the current competition, Dr. Georgi I. Petkov has submitted a reduced list of **45** scientific papers, of which **6** are defined as part of a habilitation report. Of the works, **37** are in journals indexed in the databases WoS and Scopus, and **8** are in editions without impact factor and/or impact rank. The candidate has participated in the teams of national and international projects, and the results obtained are reflected in relevant publications.

The main part of the works submitted for the competition are reports reflecting important stages in the development and application of probabilistic safety analysis (**PSA**), level 1 and level 2. They are published in proceedings of regular international conferences with high prestige in the PSA field, referred in WoS and Scopus (**SJR** indicator from **0.116** to **1.438**).

The applicant's contribution to the developed topic is indisputable, because the works are independent (**16**) or have two (**24**), three (**3**), 4 (**1**) and 7(**1**) co-authors, among whom there are foreign scientists, but Dr. G. Petkov is not the first author in only **6** of the publications.

A list of noticed citations of the applicant's works is also presented. The reference check shows that **26** are in journals covered by WoS and Scopus, **2** are in books and **16** are in non-SJR journals.

The Table submitted by the applicant for the implementation of the minimum national requirements (ZRASBG and PPZRASBG) and those of Sofia University (PURPNSZADSU) was prepared in good faith and the analysis of the evidentiary materials is in accordance with the requirements, but taking into account the corrections I noticed, he safely satisfies the indicators: of group A-50 points (acquired **50**), group B-100 points (acquired **104**), group D-200 points (acquired **312**), group D-50 points (acquired **52**).

It can be seen that with the **45** scientific publications submitted for participation in the competition, not used in previous procedures, as well as based on the other documents submitted, the applicant has or exceeds the required points in the various sections/groups of indicators, thus meeting the requirements for academic position "Associate Professor" at Sofia University.

In my opinion, there is no reason to expect some extent of plagiarism in these 45 works, since they concern new ideas and concepts that have found a response and are cited in the specialized scientific literature.

4. Characteristics and evaluation of the teaching activity of the applicant

Regarding his teaching activity at the Technical University of Sofia as a "Chief Assistant" in the College of Energy and an "Associate Professor" in the Department of "Thermal Power Engineering and Nuclear Power Engineering" of the Faculty of Power Engineering and Power Machines, Dr. G. Petkov provides information about the courses from the bachelor's and master's

programs, on which he led exercises and gave lectures. The specific topics are related to the modelling of operating and emergency modes in nuclear energy installations with consideration of reliability, diagnostics, nuclear and radiation safety, etc. The applicant is the author of the textbook "Radiation Protection" (120 pages, TU-Sofia, 2004) and led the project No. HS-1-308/2007, financed by the Bulgarian National Science Fund (BNSF) at the Ministry of Education and Science, on the topic "Development of a training program, data collection and system for evaluating the performance of students on a computer simulator of NPP with VVER." Information about the goals and results of the implementation of this project and the implementation of other ideas for improving the quality of education is given in the work [61] of the Complete List.

Based on the above, I consider that the applicant has shown activity and responsibility in teaching activities.

5. Characteristics and analysis of the applicant's scientific works and achievements

The research in the 45 scientific works presented by the applicant for participation in the competition is in the field of the safe use of nuclear technologies.

I accept and agree with the systematization in three main sections of the contribution nature of the scientific and scientific-applied results, proposed by the applicant in the presented author's reference of the contributions, but taking into account the current state of the PSA in the field, I would change their arrangement as follows:

1. Probabilistic analysis of human-machine interaction in complex installations, systems and processes: [3], [4], [7], [9], [10], [11], [12], [13], [14], [15], [16], [18], [20], [22], [23], [24], [27], [28], [30], [31], [32] , [33], [34], [35], [36], [37], [38], [39], [40], [41], [42], [43], [44], [45].

2. Probabilistic analysis of safety and accidents in complex installations, systems and processes: [3], [5], [11], [13], [15], [16], [18], [20], [21], [23], [25], [26], [27], [29], [32], [33], [34], [36], [37], [38], [39], [40], [41], [42], [43], [44].

3. Probability analysis of the reliability and risk of nuclear energy installations and devices (complex systems and processes): [1], [2], [3], [4], [6], [7], [8], [17], [19], [21], [22], [25], [26], [43], [44].

In summary, studies and analyses in the field of nuclear technologies, reliability and safety of nuclear power plants, probabilistic risk analysis and analysis of the human factor in a risky environment (including fire) have been carried out with the active leading participation of the applicant as he has focused on the important aspects of the activities and current and prospective safety technical means both in the design of reliable nuclear systems and in the management of safety during operation, planning and carrying out reconstructions.

5.1 *Main scientific and/or scientific-applied contributions of the works presented in the habilitation report* ([20], [24], [31], [40], [41], [42])

- based on an analysis of the concepts, methods and tools for supporting human performance, creating sustainable technology and implementing a reliable organization for effective decision-making and management, an approach for evaluating the human factor through a quantitative measure "context" is proposed ” as a symptom-oriented characteristic of the object-subject-situation interaction (for example, the human-operator, the organization of the technology, consideration of external influences and the safety culture (a set of characteristics of the organization and the behaviour of individuals in it));

- a method for evaluating team work and a procedure for quantifying the context based on human, organizational and technological symptoms during accidents to monitor, evaluate and analyze their development are demonstrated;

I will note that the quantification of the context is illustrated with examples including a thermo-hydraulic simulation of a severe nuclear accident, data from the use of the simulators for the training of the teams of operators of the Block Shield for Management (BSTU), as well as using the IAEA report on the accident in Fukushima (Japan) and the evaluation of a hypothetical scenario without mitigation measures at the Peach Bottom NPP (Pennsylvania, USA).

5.2 Main *scientific and/or scientific-applied contributions of works outside the habilitation report*

In my opinion, among the applicant's contributions should be noted:

- the development of a method for analysing the reliability and risk of NPP ([1-4], [6], [8], [9], [17], [19]) as topological reliability analysis of directed graphs using physical modelling graph and Petri net techniques, which is an alternative approach to the traditional fault tree method;

- due attention is paid to the management of the aging of the systems by assessing and forecasting the condition of the facilities by means of the analysis of equipment failure databases and the determination of: a) safety-important components and arrangements and the assessment of their residual resource; b) identification of dominant mechanisms of aging of certain components and development of effective methods for monitoring and delaying the aging process. In works [25], [26] and [29] methods of analysis of the topological reliability of oriented graphs were developed and applied, and a sensitivity analysis of the aging effects of a NPP safety system - a three-channel system for removing not on residual heat and low-pressure feed for VVER-1000/B320 reactor.

The analysis of the publications presented by the applicant allows us to conclude that he has participated actively and at a high professional level in the development and use of the probabilistic approach for quantitative assessment of risk to public health and safety, taking into account the design, maintenance activities and practices in complex systems such as nuclear power plants. Probabilistic risk assessments typically focus on accidents that could seriously damage the reactor core and could cause radioactivity to be released into the environment due to containment compromise. I believe that the candidate has made a significant contribution to each of the areas in which he has worked.

6. Critical remarks and recommendations

I have no significant critical remarks regarding the presentation of the considered problems, the approaches to setting and solving the tasks, and the results obtained.

I would like to point out that in several of the scientific works submitted for the competition, the applicant uses the term "context", introduced as a measure for quantitative evaluation of the human factor in accident analysis. In this regard, I have the following questions on which I would highly appreciate the applicant's comments:

- does the candidate think that today there is a consensus reached on a common formulation of "context" when defining it as a unique quantitative measure?

- Fig. 2 - 10 in [40] presents the dependence of the context probabilities on time for different cases, and the graphs show 2 plots, without commenting on the purpose of the individual plots;

- in Fig. 5 in [42] there is a difference between the displayed context plot for 208 min (a) and the unfolded version for 116.5-123.5 min (c).

I recommend the applicant consider publishing the ideas and results in reputable high-impact journals to share innovations and disseminate expertise in nuclear technology.

7. Personal impressions of the applicant

I have known the applicant from his early steps in the company "Risk Engineering" Ltd. for the development and application of methods, algorithms, and software tools for applying the probabilistic approach in analysing the safety of complex systems, including NPP systems. I think that the applicant is currently among the leading specialists in this field, not only in our country, and with his rich professional experience, he will have a positive influence on the education of personnel for nuclear energy at the Faculty of Physics of SU.

8. Conclusion on the application

After having familiarized myself with the materials and scientific works presented in the competition and based on the analysis of their significance and the scientific and scientific-applied contributions contained in them, I confirm that the scientific achievements meet the requirements of ZRASRB, the Regulations for its application and the relevant Regulations of SU "St. Kliment Ohridski" for the candidate to occupy the academic position of "Associate Professor" in the scientific field and professional direction of the competition.

I believe that the presented scientific works have the necessary argumentation of the scientific and scientific-applied contributions, and the candidate appears as a highly qualified

specialist with proven experience in developing and applying methods and means to implement the probabilistic approach when analysing safety in nuclear technologies.

The candidate meets the minimum national requirements in the professional direction and no plagiarism has been found in the scientific works submitted for the competition. There is convincing evidence that Dr. Georgi Petkov is a well-rounded researcher and lecturer who meets the requirements for the position of "Associate Professor" in the Faculty of Physics at SU "St. Kliment Ohridski". I give my positive assessment to the application.

II. OVERALL CONCLUSION

Based on the above, I strongly recommend the respected scientific jury to propose to the competent authority for the selection of the Faculty of Physics at SU "St. Kliment Ohridski" to elect Dr. Georgi Ivanov Petkov to occupy the academic position of "Associate Pprofessor" in the professional field of Physical Sciences (Probability Analysis in Nuclear Technologies), code 4.1.

November12, 2022. Prepared by the reviewer:

Professor Doctor of Science Kiril Krezhov

(academic position, scientific degree, name, surname)