TOMSK POLYTECHNIC UNIVERSITY ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

APPROVED BY

Director of ~~Nuclear~~ Science & Engineering School
_____ / Oleg Yu. Dolmatov
"25" 06 2020

Course Name:
Development of Basic Solutions for NPP Construction Team Project

Field of Study: Nuclear Physics and Technology

Programme name: Nuclear Science and Technology

Specialization: Nuclear Power Engineering

Level of Study: Master Degree Programme

Year of admission: 2019

Semester, year: semester 3, year 2

ECTS: 3

Total Hours: 108

Contact Hours: 48

- **Lectures:** 16
- **Practical experience:** 16
- **Lab:** 16

Self-study: 60

Assessment: Exam, graded credit-test

Division: Nuclear Fuel Cycle

Director of Programme _____ / Vera V. Verkhoturova

Instructor _____ / Boris P. Stepanov

TOMSK POLYTECHNIC UNIVERSITY ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

Course name: Development of Basic Solutions for NPP Construction Team Project

Course Overview

Course Objectives	The objectives of the training course "Development of Basic Solutions for NPP Construction Team Project" is the formation of a set of competencies, which are required for a specialist to be prepared for production, technological and engineering activities in the field of nuclear energy. The discipline is devoted to familiarizing students with the theoretical and practical issues underlying the construction and operation of modern nuclear power plants, as well as with the principles and algorithms for developing engineering solutions for the project to create nuclear power plants, safety systems and equipment.
Learning Outcomes	**Upon completion of the course, a graduate will obtain the knowledge of:** – main types, classes and groups of materials, their composition and properties (nuclear fuel, heat carriers, retardants, structural materials, protection materials); – existing designs of nuclear reactors in general and their structural elements; – the behavior of various materials of nuclear reactors and power plants under the influence of ionizing radiation and complex temperature fields; – the fundamental design solutions of the nodes and elements of the safety systems of the reactor installation; – the main directions of creating fundamentally new nuclear reactors and power plants that meet modern safety and environmental requirements. **Upon completion of the course, graduates are also expected to develop the following skills:** – determine the critical characteristics of controls and elements of safety systems at any time during operation of the reactor; – apply methods of modeling, calculation and experimental research in the development of safety systems for nuclear reactors; – analyze the design decisions of the developed and created power plants at nuclear power plants; – perform an estimated engineering calculation of the structure and equipment, devices of physical protection systems of a nuclear facility; – analyze and interpret the security of nuclear materials, nuclear reactors at nuclear power plants; – draw up technical documentation (work schedules, instructions, plans, estimates, requests for materials, equipment, operating instructions); – take into account the specifics of nuclear energy in the formation of a socially objective attitude of the population to the problems of the development of the electric power industry. **Upon completion of the study of all sections of the discipline, students will gain practical experience in the field of:** – application of knowledge acquired for designing in conditions when there are no standard developments; – calculation of safe operating modes of nuclear reactors;

	– preparation of schemes, graphs, drawings, diagrams, nomograms and other professionally significant images; – the use of knowledge acquired to solve specific problems, for comparative assessments with experience in calculating the effectiveness of security systems and components of control systems.
Course Outline	The target course is taught using a variety of teaching forms such as: – 8 lectures; – 8 practical experiences; – 3 laboratory activities; – 2 tests; – group project; – term paper. The course consists of 5 sections, which are given below. **Section 1. Introduction** **Section 2. Safety Assessment during NPP Operation** **Section 3. Design of NPP safety systems** **Section 4. Basic Procedures for the Physical Protection of Nuclear and Radioactive Materials, Nuclear Installations** **Section 5. Justification and development of design solutions** Each section includes several lectures, practical experiences and a laboratory activity. The course ends with an exam, the defense of the course project ends with a pass-fail grading test. As part of the study of the discipline, students must prepare and defend an abstract, complete a group project and a course project. The training course provides for the implementation of 2 tests to check the development of trainees' knowledge and skills. The term project for the training course includes the following tasks to be done by students: 1. The choice of the location of the nuclear facility site, taking into account external factors and environmental features. 2. The choice of the structure of the facility and the location of the main production sites. 3. Setting the boundaries of a nuclear facility. 4. Definition and description of the type of nuclear reactor. 5. Setting the main characteristics of nuclear fuel, a description of the layout of the core of a nuclear reactor. 6. Establishment of the location and movement of fuel assemblies. 7. Organization of a checkpoint at the facility. 8. Implementation of work on equipping the checkpoint with engineering and technical security equipment.
Course Structure	The content of the course covers 5 topics. Each topic is studied through lectures, practical experiences and laboratory activities. **Section 1. Introduction** Safety issues during the construction and operation of nuclear power plants. **Section 2. Safety Assessment during NPP Operation** Conditions for the safe use of atomic energy. The main IAEA approaches to safety justification at the stages of the nuclear fuel cycle (NFC). Ensuring requirements for nuclear and radiation safety at nuclear facilities. Conditions

	for the normal operation of a nuclear power plant (NPP). Factors that create threats to nuclear activities at nuclear facilities. Nuclear security culture. **Section 3. Design of NPP safety systems** Identification of goals and objectives fulfilling security systems. Stages of designing a nuclear power plant, the sequence of their implementation. Criteria for evaluating security systems. Pre-design stage: collection of initial data, formalization of the task, analysis of technical conditions of functioning. Development of a conceptual project. The choice of structures of security systems, the formulation of requirements for the constituent elements. Criteria of reliability and performance. Assessment of the effectiveness of systems. The influence of the human factor. **Section 4. Basic Procedures for the Physical Protection of Nuclear and Radioactive Materials, Nuclear Installations** Regulatory support of physical protection during the handling of nuclear materials, operation of nuclear reactors. Ensuring nuclear and radiation safety at a nuclear facility. Special handling of nuclear materials. Implementation of methods, procedures for accounting and control of nuclear materials. Organization of physical protection of nuclear materials, nuclear facilities at a nuclear facility. Creation and operation of a physical protection system at the facility. Information security in automated systems of nuclear power plants. **Section 5. Justification and development of design solutions** Safety justification for nuclear facilities. Stages of designing a nuclear power plant. The choice of the structure of security systems and support. Justification of the working draft. The choice of security system structure. Justification of design decisions of systems and elements.
Facilities and Equipment	1. Lecture hall: Tomsk, Lenin Ave. 2,building 10, room 313 2. Research laboratory: Tomsk, Lenin Ave. 2, building 10, room 312 3. Lecture hall: Tomsk, Lenin Ave. 2,building 10, room 248 Laboratory of security systems and counteraction to nuclear terrorism is used to perform lab works: - A complex of security systems and CCTV - Training system for ensuring the safety and physical protection of nuclear facilities - Means of access control (filling devices, sealing objects, cable cutter, wire cutters) - Laminator for making passes - Machine for cutting special plastic materials.
Grading Policy	In accordance with TPU rating system we use: – Current assessment which is performed on a regular basis during the semester by scoring the quality of mastering of theoretical material and the results of practical activities (performance tests, perform tasks, problem solving). Max score for current assessment is 40 points, min – 22 points. – Course final assessment (exam/ credit test) is performed at the end of the semester. Max score for course final assessment is 60 points, min – 33 points. The final rating is determined by summing the points of the current assessment during the semester and protection of the course project at the end of the semester. Maximum overall rating corresponds to 100 points, min pass score is 55.
Course Policy	Attendance is strictly controlled. All classes are obligatory for attendance.

Teaching Aids and Resources	**Compulsory reading:** 1. Oka Y. Nuclear Reactor Design / Y. Oka. – Tokyo : Springer, 2014. – 327 p. – Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-4-431-54898-0 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. 2. Zohuri B. Thermal-Hydraulic Analysis of Nuclear Reactors / B. Zohuri, N. Fathi. – Cham : Springer International Publishing, 2015. – 651 p. – Текст : электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-3-319-17434-1 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. 3. Kessler G. Sustainable and Safe Nuclear Fission Energy. Technology and Safety of Fast and Thermal Nuclear Reactors / G. Kessler. – Berlin : Springer-Verlag, 2012. – 464 p. – Текст : электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-3-642-11990-3 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. **Additional reading:** 1. Крайнов А В. Тепловые процессы в энергосистемах = Heat Processes in Energy Systems : учебное пособие / А. В. Крайнов, Г. В. Швалова. – Томск : Изд-во ТПУ, 2013. – URL : http://www.lib.tpu.ru/fulltext2/m/2013/m167.pdf (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. – Текст : электронный
Instructor	Вкю Boris P. Stepanov, Assistant professor, Nuclear Fuel Cycle Division, School of Nuclear Science and Engineering, TPU, e-mail: sbp@tpu.ru, phone: +7 (3822) 701-777 (ext. 2259), personal site: https://portal.tpu.ru/SHARED/s/SBP/eng