TOMSK POLYTECHNIC UNIVERSITY | ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

APPROVED BY

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

Course Name: Operation of Nuclear Power Plant Equipment

Field of Study: Nuclear Science 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:** 24
- **Labs:** 16
- **Practical experience:** 8

Self-study: 60

Assessment: Exam

Division: Nuclear-Fuel Cycle

Director of Programme _____ / Vera V. Verkhoturova

Instructor _____ / Konstantin V. Slyusarskiy

TOMSK POLYTECHNIC UNIVERSITY ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

Course name: Operation of Nuclear Power Plant Equipment

Course Overview

Course Objectives	The objective of mastering the discipline is the formation of certain set of student's competence to prepare them for professional activities. Current course is aimed to form a following competences: 1. Able to run the project on different stages of its life cycle. 2. Able to apply modern communication technology for academic and professional interactions including those on foreign language. 3. Able to formulate goal and objectives of research, chose evaluation criteria, prioritize solution of tasks. 4. Able to manage the personnel considering behavior motives and methods of personnel professional behavior development, apply methods for evaluation of quality and results of personnel work, develop and implement means of prophylaxis and prevention of industrial injuries, prevention of ecological failures. 5. Able to analyze technical and calculation-theoretical solutions, consider their accordance to requirements of law in field of industry, ecology, safety and other normative acts.
Learning Outcomes	Upon completion of the course, a graduate **will obtain the knowledge of:** – the stages of project development and implementation; – the basics of structuring a report and preparing presentations in a foreign language (English), accepted in the international practice; – the goals and objectives of scientific research in the field of professional activity, basic principles and methods of their organization; – the main sources of scientific information and the requirements for the presentation of information materials; – the patterns of influence of identified defects on the technical condition of the equipment of the owner unit; – the technical conditions, standards for installation, repair, commissioning, testing of equipment assigned to NPP units; – the characteristics of equipment, components, materials and semi-finished products supplied to nuclear facilities to assess their compliance; – the methods of modeling, calculation and experimental research for the development of new nuclear reactors and power plants; – the methods for calculating the main characteristics of nuclear power plants. Upon completion of the course, graduates are also expected to develop the following **skills:** – to apply methods of development and project management; – to apply methods for assessing resource requirements and project effectiveness; – of monologue utterance in a foreign language (English) according to the profile of his specialty, reasonably expounds his position and using auxiliary means (tables, graphs, charts, etc.);

	– to apply acquired knowledge of a foreign language (English) at a sufficient level in his future professional activities; – to apply possessed systematic knowledge in the field of activity; – of determining the degree of influence of identified defects on the technical condition of the equipment of the owner unit; – of performing engineering calculations of the main systems and equipment of the station; – of conducting thermohydraulic calculation of equipment of nuclear power plants; – of building schemes, graphs, drawings, diagrams, nomograms and other professionally significant images; – of solving specific technical problems in the design and operation of NPP equipment; – of calculating the efficiency of operation of equipment and reactor control and protection systems. Upon completion of the course, graduates should acquire **the practical experience in**: – developing a project taking into account the analysis of alternative options for its implementation, determine the target stages, the main directions of work; – managing a project at all stages of its life cycle; – compiling and present technical and scientific information used in professional activities in the form of a presentation; – drawing up a general plan of work on a given topic, suggest research methods and methods of processing the results; – applying optimization methods when planning activities for the design, operation, repair and commissioning of NPP equipment; – determining the degree of influence of identified defects on the technical condition of the equipment of the owner unit; – making safety assessments of existing and planned nuclear power plants; – analyzing design decisions of existing and planned power plants; – calculations of the main characteristics of nuclear power plants; – drawing up technical documentation (work schedules, instructions, plans, estimates, requests for materials, equipment, operating instructions); – making estimates of the integral indicators of the station.
Course Outline	The target course is taught using a variety of teaching forms such as: – 12 lectures; – 8 labs; – 4 practical experiences; – 4 individual homework assignments; – 8 lab reports. The course consists of 12 sections, which are indicated below. Section 1. Introduction. Types of thermomechanical equipment of NPP. Section 2. Main indicators of NPP. Typical values of the main parameters of NPP, connection with the operational characteristics of the equipment of NPP. Section 3. Main and auxiliary systems of NPP. Equipment of the main and auxiliary systems of NPP. Section 4. Discharging equipment of NPP. Pumps, fans and compressors: classification, principle of operation, design and basic operation.

	Section 5. Condensers of nuclear power plants: operating principle, design and operation fundamentals. Characteristic features of NPP condensers. Section 6. Separators and intermediate superheaters of NPP: classification, principle of operation, design, basics of calculation and operation. Section 7. Deaerators of NPP: classification, principle of operation, design, basics of calculation and operation. Section 8. Regenerative heaters of NPP: classification, principle of operation, design and operation fundamentals. Section 9. Reduction devices of NPP. Pipelines and fittings of NPP. Section 10. Main reactor circuit and its auxiliary systems. Each section includes several lectures, labs and/or practical experiences. The course ends with an ecamination. *Learners' self-study* is arranged in a form of individual homework assignments and individual research of the topics. During the course of study, learners are expected to complete 4 individual homework assignments. *Individual homework assignment* is a set of tasks each containing unique set parameters. It is obligatory for each student to present the results of individual homework assignment completion in a form of a report. The report must have a title page, initial data, task solution, conclusions, and final statement. The report must be defended in class. This suggests students answering from 3 to 5 questions related to the topic of the assignment. *Lab* is performed in groups of 2-3 students. Each group receive their individual set of data. The results of lab performance must be presented in a report. The report must have a title page, initial data, description of solution methods, solution, conclusions, and final statement. The report must be defended in a class by the group. This suggests each student within a group answering up to 3 questions related to the topic of the assignment.
Course Structure	The content of the course covers 12 topics. Each topic is studied through lectures, practical experiences and labs. **Section 1. Introduction. Types of thermomechanical equipment of NPP.** The content and construction of the course. Compulsory Reading. Course terminology. Classification and characteristic features of NPP of various types. Types, role and position of the technological equipment of a NPP. The main and auxiliary equipment of NPP. The concept and equipment of the reactor and turbine sections of NPP. Condensation and cogeneration plants. **Lecture topic:** 1. Introduction, content and structure of the course. Classification of NPP and their characteristic features. The main thermomechanical equipment of NPP of various types. **Section 2. Main indicators of NPP. Typical values of the main parameters of NPP, connection with the operational characteristics of the equipment of NPP.** The main indicators of the overall and thermal efficiency of NPP operation in condensation and cogeneration modes. Initial and final parameters of the working fluid of a NPP: typical values for existing stations, limitations, conection with the performance of the station in general. The relationship between the main parameters of the NPP with the characteristics of a particular equipment. **Lecture topic:** 2. The main indicators of NPP. Initial and final parameters of the working fluid of

	NPP. The relationship between the main parameters and characteristics of the equipment of NPP. **Practice topic:** 1. Change in operating parameters of NPP during the transition to a cogeneration mode of operation. **Section 3. Main and auxiliary systems of NPP. Equipment of the main and auxiliary systems of NPP.** A list of the main systems of the reactor and turbine compartments, their technological schemes. The principal thermal scheme of NPP: the content, requirements, principles of construction and designation of the main equipment. Basics of calculating thermal schemes of NPP. Characteristic features of the basic thermal schemes of existing NPP. Lecture topic: 3. Schematic diagram of the NPP. Technological schemes of systems of reactor and turbine equipment of NPP. Lab topic: 1. The study of the principal thermal scheme of NPP with WWER-type reactor. **Section 4. Discharging equipment of NPP. Pumps, fans and compressors: classification, principle of operation, design and basic operation.** Discharging equipment of NPP. Pumps: role, classification, principle of operation. Fundamentals of engineering hydraulic calculations of networks and pump selection. Main characteristics, switching and regulation circuits. Cavitation: definition, causes, methods of prevention. Features of the design and operation of condensate, feed water and drainage pumps. Design and operation features of the main circulation pump and reactor compartment pumps. Devices for increasing pressure and transportation of gaseous media: role, classification, principle of operation, calculation basis. Design features of compressors and gas blowers of NPP. **Lecture topics:** 4. Pumps: role, classification, principle of operation. Cavitation. Design, fundamentals of calculation and operation of NPP pumps. 5. Compressors, gas blowers and fans: role, classification, principle of operation. Design, basics of calculation and operation of compressor equipment of NPP. **Lab topic:** 2. Testing of centrifugal fan. 3. Tests of the reciprocating compressor. 4. Study of the design of the main circulation pump. 5. Study of the design of the feed and condensation pumps. **Section 5. Condensers of nuclear power plants: operating principle, design and operation fundamentals. Characteristic features of NPP condensers.** NPP codensers: classification, operating principle, design and operation fundamentals. The place on the thermal scheme and the effect of the condenser on the characteristics of the NPP. Compensation of thermal expansions. Ejection of non-condensable gases. Characteristic features of NPP condensers. Selection and justification of the pressure in the condenser. **Lecture topic:** 6. Condensers of NPP. Design and principle of operation. Basics of calculation and operation features. Ejection of a vapor-air mixture. **Practice topic:** 2. The effect of the design parameters of the condenser and cooling water on the

	final pressure. **Section 6. Separators and intermediate superheaters of NPP: classification, principle of operation, design, basics of calculation and operation.** Separation and intermediate superheating of steam: purpose, types, effect on the characteristics of NPP. Selection of optimal parameters for separation and intermediate overheating. The principle of operation of separation devices, steam and fire overheating of steam at NPP. Design and operation fundamentals of a superheater of a NPP. **Lecture topic:** 7. Separators and intermediate superheaters of NPP: classification, principle of operation, design and operation fundamentals. **Section 7. Deaerators of NPP: classification, principle of operation, design, basics of calculation and operation.** Deaeration of feed water at NPP: necessity, methods, characteristic parameters. Deaerators of NPP: purpose, design, operating principle, basics of calculation and operation. The inclusion scheme and placement in the building of deaerators of NPP. **Lecture topic:** 8. Deaeration of feed water at NPP. Design and principle of operation of deaerators. Fundamentals of calculation and operation of deaerators of NPP. **Practice topics:** 3. The effect of deaeration pressure on the parameters of NPP. **Section 8. Regenerative heaters of NPP: classification, principle of operation, design and operation fundamentals.** Heat recovery of the working fluid at NPP: necessity, methods, effect on the characteristics of the station. Regenerative heaters of NPP: purpose, design, principle of operation, basics of calculation and operation. The conditions for the inclusion of a steam cooler and drainage cooler, design and basic operation. Schemes for including regenerative heaters and drainage coolers in the feedwater circuit. **Lecture topic:** 9. Regeneraton. Design and principle of operation of regenerative heaters of NPPlants. Basics of calculation and operation of heaters. **Practice topic:** 4. The effect of regenerative heating on the characteristics of NPP. **Section 9. Reduction devices of NPP. Pipelines and fittings of NPP.** Reduction and reduction-cooling devices: purpose, design, principle of operation and operation fundamentals. Pipelines of NPP: materials, fastening, insulation. Fittings: types, purpose, design. Features of pipelines and fittings of NPP. **Lecture topic:** 10. Reduction and reduction-cooling devices of NPP: purpose, design, principle of operation. Pipelines and valves of NPP: types, materials, design. **Section 10. Main reactor circuit and its auxiliary systems.** The main and auxiliary systems for the normal operation of the reactor compartment: functions, operating principle, scheme and composition of equipment. Design and operating principle of pressurizer. Systems for maintaining the quality of the coolant, boron regulation and organized leaks. Emergency systems of the reactor compartment: task, operating principle, scheme and composition of equipment. Emergency power supply systems and core cooling. The concept of the circuit of natural circulation (CEC). Calculation of the driving

	pressure along the natural circulation circuit and its determining factors. **Lecture topic:** 11. Systems for normal operation of the reactor compartment: functions, operating principle, scheme and composition of equipment. 12. Emergency systems of the reactor compartment: functions, operating principle, scheme and composition of equipment. **Lab topic:** 6. Studying the equipment of the special gas treatment system. 7. The study of the equipment of the reactor compartment of a NPP with a pressurized water coolant. 8. The study of the equipment of the reactor compartment of NPP with a molten metal coolant.
Facilities and Equipment	1. Lecture Hall with multimedia equipment: Tomsk, Lenin ave. 30a, build. 4, room 301. 2. Lecture Hall with multimedia equipment: Tomsk, Lenin ave. 30a, build. 4, room 31.
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 (control tests, defense of individual task and lab reports). Max score for current assessment is 80 points, min – 44 points. – Course final assessment (exam) is performed at the end of the semester. Max score for course final assessment is 20 points, min – 11 points. The final rating is determined by summing the points of the current assessment during the semester and credit test scores 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. Breeze, P. Combined Heat and Power [Электронный ресурс] / P. Breeze. — Электрон. дан. — Elsevier Ltd.: Academic press, 2018. — 95 p. — Режим доступа: https://ezproxy.ha.tpu.ru:2056/book/9780128129081/combined-heat-and-power. — Загл. с экрана. **Additional reading:** 1. Structural Materials for Generation IV Nuclear Reactors [Электронный ресурс] / edited by Pascal Yvon. - Электрон. дан. — Elsevier Ltd.: Woodhead Publishing, 2017. -664 p. - Режим доступа: https://www.sciencedirect.com/book/9780081001493/handbook-of-generation-iv-nuclear-reactors. - Загл. с экрана.
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