TOMSK POLYTECHNIC UNIVERSITY | ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

APPROVED BY

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

Course Name:
Nuclear Material Accountancy and Inventory Control of Other Radioactive Material

Field of Study: Nuclear Science and Technology

Programme name: Nuclear Science and Technology

Academic profile: Nuclear Safety, Security and Non-Proliferation of Nuclear Materials

Level of Study: Master Degree Programme

Year of admission: 2020

Semester, year: semester 2, year 1

ECTS: 5

Total Hours: 180

Contact Hours: 80

- **Lectures:** 24
- **Practical experience:** 16
- **Labs:** 40

Self-study: 100

Assessment: Exam, term paper

Division: Nuclear Fuel Cycle

Director of Programme _____ / Vera V. Verkhoturova

Instructor _____ / Maxim E. Silaev

TOMSK POLYTECHNIC UNIVERSITY ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

Course name:
Nuclear Material Accountancy and Inventory Control of Other Radioactive Material

Course Overview

Course Objectives	The objective of the training course "Nuclear Material Accountancy and Inventory Control of Other Radioactive Material" is to teach students to define and describe the organization of International and National systems of accounting and control of nuclear and other radioactive material. Trainees will be able to arrange national nuclear accountancy and control systems at bulk and um facilities, perform national inspections, analyze and report results of physical inventory taking (PIT) as a part of International nuclear security measures. Special attention will be paid to the performance of national inspections and PIT activities. This course will help students to solidify their knowledge about international safeguards, the IAEA's function, international safeguards measures and activities**.**
Learning Outcomes	**Upon completion of the course, a graduate will obtain the knowledge of:** – the basic methods, procedures and technologies which are used at the nuclear fuel cycle plants to provide nuclear materials safe management; – the main regulatory documents of IAEA for organization and functioning of the National system of nuclear material accounting and control at all levels. **Upon completion of the course, graduates are expected to develop the following skills:** – to analyze and compare International and National Nuclear material accounting and control programs (NMAC); – to categorize nuclear materials according to regulatory documents; – to organize material balance areas and key measurement points at a nuclear facility; – to analyze the physical inventory taking for a selected category of nuclear material; – to prepare accounting and reporting documentation; – to develop NMAC program for hypothetical nuclear fuel cycle facility. **Upon completion of the course, graduates should acquire the practical experience in:** – application of the acquired knowledge for designing NMAC system; – planning and conducting physical inventory taking of nuclear materials; – using the obtained knowledge to apply tamper-indicating devices in NMAC program; – measuring the mass of samples as a part of physical inventory taking of nuclear materials; – creation of barcode label for inventory item.
Course Outline	The training course is delivered through the following teaching modes: – 12 lectures; – 8 practical experiences; – 20 labs;

	– 1 term project paper. The course consists of 6 sections, which are given below. **Section 1. International and domestic requirements for accounting and control of nuclear materials at nuclear power plants.** **Section 2. Nuclear Material Accounting.** **Section 3. Nuclear material controls.** **Section 4. Movement of nuclear and radioactive materials.** **Section 5. Measurements.** **Section 6. Assessment and performance testing of the NMAC system.** Each section includes several lectures, practical and laboratory experiences. Laboratory experiences aim to train students to obtain practical skills such as planning and conducting physical inventory taking of nuclear materials. Students will be able to measure the mass of samples as part of a physical inventory taking, and to determine and evaluate the error of the results. They will become familiar with practical use of tamper-indicating devices, their installation methods and integrity control. They will also learn barcode labeling techniques, become capable of creating their own barcode to identify hypothetical accounting units. The training course finishes with an exam and requires obligatory completion and defense of a term paper. As part of the study, the course provides for writing and defending a report as students' self-study activity. Report is scored with the maximum of 10 points. The term paper includes the following tasks: 1. Development of the basic project for the organization of material balance area at a nuclear facility. The study of technological processes associated with the circulation of nuclear and radioactive materials at individual sites, stages of the nuclear fuel cycle. 2. Allocation of methods and ways of moving nuclear and radioactive materials on the territory of a nuclear facility. 3. Categorization of nuclear material 4. Allocation of material balance area. 5. Allocation of key measurement points 6. Analysis of the physical inventory procedure for the selected category of nuclear materials. 7. Study of procedures for measuring nuclear materials and compiling accounting and reporting documents The course implies conducting 2 intermediate tests. Each test is scored with the maximum of 5 points.
Course Structure	The content of the course covers 6 topics. Each topic is studied through lectures and practical experiences. **Section 1. International and domestic requirements for accounting and control of nuclear materials at nuclear power plants** Introduction to nuclear materials accounting and control (NMAC). Nuclear fuel cycle facilities and special handling of nuclear materials. National and international guarantees on the non-proliferation of nuclear materials. Features of the establishment of NMAC system in the Russian Federation. **Section 2. Nuclear Material Accounting** Material balance areas. Physical inventory taking of nuclear material. Varieties of physical inventory takings. Physical inventory planning. The sequence and content of planning the physical inventory taking stages.

	Section 3. Nuclear material controls Two-person rule. Tamper-indicating devices. Physical protection measures for control. Video observation system and sealing devices. Administrative checks. **Section 4. Movement of nuclear and radioactive materials** Storage and working areas. Nuclear material and radioactive waste flows and key measurement points. The implementation of access control tools and accounting and control procedures in various zones of a nuclear facility at all stages of the movement of nuclear material. **Section 5. Measurements** Destructive and non-destructive analysis. Barcode technology in the NMAC system. The basics of reading barcodes. Classification of codes by type and scope. Codes and symbols used. **Section 6. Assessment and performance testing of the NMAC system** Methods of assessing the physical inventories effectiveness. Performance Evaluation Criteria in the NMAC system. The elements interaction of NMAC system and Physical protection system of nuclear material.
Facilities and Equipment	1. Lecture Hall with multimedia equipment: 634050, Tomsk, Lenin ave. 2, building 10, room 228 2. Laboratory classroom: 634050, Tomsk, Lenin ave. 2, building 10, room 314.
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 80 points, min – 44 points. – Course final assessment (exam/ credit test) 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 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. Nuclear Non-proliferation and Arms Control Verification. Innovative Systems Concepts / by editors I. Niemeyer, M. Dreicer, G. Stein. - Cham : Springer, 2020. — XV, 455 p. — Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-3-030-29537-0 (дата обращения: 20.09.2020). – Режим доступа : по подписке. 2. Nuclear Non-Proliferation in International Law : in 5 volumes. Vol. 3. Legal Aspects of the Use of Nuclear Energy for Peaceful Purposes / by editors J. L. Black-Branch, D. Fleck. — Berlin : Springer Verlag, 2016. — XIII, 556 p. — Текст : электронный // SpringerLink. — URL: https://link.springer.com/book/10.1007/978-94-6265-138-8 (дата обращения: 10.04.2020). — Режим доступа : по подписке. 3. Morse, E. C. Analytical Methods for Nonproliferation / E. C. Morse. — Cham: Springer International Publishing, 2016. — XIII, 250 p. — Текст : электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-3-319-29731-6 (дата обращения:

	20.09.2020). – Режим доступа : по подписке. 4. Nuclear Threats and Security Challenges / by editors S. Apikyan, D. Diamond. — Dordrecht : Springer 2015. — IX, 285 p. — Текст : электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-94-017-9894-5 (дата обращения: 20.09.2020). – Режим доступа : по подписке. **Additional reading:** 1. Analysis of questions concerning the nonproliferation of fissile materials for low-and medium-capacity nuclear power systems / V. V. Petrunin, V. I. Polunichev, Yu. P. Sukharev [and etc.]. - Текст электронный // Atomic Energy. – 2008. - Vol. 105, № 3. – P. 159-164. - URL: https://link.springer.com/article/10.1007/s10512-008-9081-2 (дата обращения: 20.09.2020). – Режим доступа : по подписке.
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