Course guide
240NU014 - 240NU014 - Fuel Cycle and Environmental Impact

Last modified: 16/04/2024

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 748 - FIS - Department of Physics.

Degree: MASTER'S DEGREE IN NUCLEAR ENGINEERING (Syllabus 2012). (Compulsory subject).

Academic year: 2024 **ECTS Credits:** 5.5 **Languages:** English

LECTURER

Coordinating lecturer: ARTURO VARGAS DRECHSLER

Cortes Rossell, Guillem Pere

Others:

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Have a clear and wide the entire energy conversion chain of nuclear fuel in final energy, ranging from mining to spent nuclear fuel management.
2. Ability to assess the environmental impact of a nuclear facility, both in operation and in the rest of the life cycle.
3. Ability to use effectively, understand the operation and validity ranges, and interpret the results of calculation codes dose estimate emission of radionuclides to atmosphere.

TEACHING METHODOLOGY

master class and monitored sessions

LEARNING OBJECTIVES OF THE SUBJECT

1. Describe and explain the need of different stages in the nuclear fuel cycle.

2. Analyse statistical data related to the nuclear fuel cycle.

3. Characterise the types of nuclear fuel and describe the techniques of exploration and extraction of uranium and thorium.

4. Describe the methods of isotopic enrichment.

5. Describe the methodology used in the production of fuel elements and calculation processes

6. Calculate the cost of a complete fuel element and compare this cost to the energy provided by that element.

7. Describe the properties of spent nuclear fuel

8. Analyse options for temporary storage of spent fuel and storage strategies.

9. Identify the type of containers used to transport spent fuel and the regulations applied nationally and internationally.

10. Explain the concepts associated with the treatment of spent nuclear fuel, analyse current and proposed processes and describe the characteristics of MOX fuel.

11. Describe and identify the technologies for the treatment, burning, generation and transmutation of spent nuclear fuel.

12. Identify the emission sources of radioactive contaminants in nuclear facilities (or not nuclear) and characterisation of radionuclides emitted.

13. Quantify emissions of radioactive substances from nuclear and radioactive facilities.

14. Assess the transportation of radionuclides in the environment and the incorporation of them to the food chain.

15. Analyse the radiological impact of nuclear and radioactivity facilities.

16. Estimate, using the appropriate calculation tools, external and internal doses received due to radioactive emissions to the environment (simple cases).

17. Describe the environmental radiation monitoring systems and associated instrumentation.

18. Establish the methodology to demonstrate that the site is in compliance with a radiation dose or risk-based regulation.

STUDY LOAD

Type	Hours	Percentage
Hours small group	5,5	4.06
Self study	86,0	63.47
Hours large group	44,0	32.47

Total learning time: 135.5 h

CONTENTS

1. Mining, conversion and isotopic enrichment of uranium

Description:
Students will gain a general overview of the nuclear fuel cycle and the uranium resources in the world. Also the student will be able to describe the main methods uranium enrichment and mining techniques. The learning of this topics will be alternated with theory and problems.

Specific objectives:
CE11

Related activities:
- 0.5h Presentation (Theory-GC AV)
- 1.5h Introduction to Nuclear Fuel Cycle (Theory-GC)
- 3.0h Mining and conversion (Theory-FT)
- 1.0h Mining and conversion (Problems-FT)
- 3.0h Isotopic enrichment (Theory-FT)
- 1.0h Isotopic enrichment (Problems-FT)

Full-or-part-time: 13h
Theory classes: 8h
Practical classes: 2h
Self study : 3h

2. Design and fabrication of nuclear fuel

Description:
The student will be able to describe the process employed for the design on nuclear fuel and its thermo-mechanical properties and limitations. The class will be done by Spanish experts on nuclear fuel fabrication from ENUSA (Spanish nuclear fuel fabrication facility)

Specific objectives:
CE11

Related activities:
- 3.0h Mechanical design and fabrication of nuclear fuel. (Theory, MA)
- 3.0h Thermo-mechanical design of nuclear fuel (2h Theory and 1 h problems, CM)
- 6.0h Visit to a Fuel Assembly Factory (Laboratory-ENUSA)

Full-or-part-time: 15h
Theory classes: 5h
Practical classes: 1h
Laboratory classes: 6h
Self study : 3h

3. Management of spent nuclear fuel

Description:
By the end of this topic, the student will be able to classify radioactive wastes and describe the methods for safely storage of spent fuel. Also the student will be able to calculate the main composition of spent fuel, the activity and power dissipated over a period of time.

Specific objectives:
CE11

Related activities:
- 3.0h Classification of radioactive waste, sources, examples and properties. (Theory-GC)
- 3.0h Storage of spent fuel and transportation (Theory-GC)

Full-or-part-time: 10h
Theory classes: 6h
Self study : 4h

4. Reproduction and advanced cycles

Description:
The students should read the information given by the teacher before the class. At class the teacher explains the basic concepts and answers questions proposed by the students (1 hour). After the theoretical session, the students should begin the resolution of a problem (1 hour) and finish it out of class.

Specific objectives:
CE11

Related activities:
- 2.0h The PUREX process, transmutation, and fast reproduction reactors. (1h Theory and 1h problems, GC)

Full-or-part-time: 7h
Theory classes: 1h
Practical classes: 1h
Self study : 5h

5. Source term and transport in the environment

Description:
The student will acquire the basic concepts of the radioactive source term and its transport in the environment. The students will apply the concepts using models for estimating the radiological impact of radiological discharges to the environment. At least the code CROM will be use in class in practical exercise.

Specific objectives:
CE12, CE14

Related activities:
- 2.0h Source term (Theory AV)
- 2.0h Transport (Theory AV)
- 4.0h Environmental impact code CROM (1 theory and 3h problems JCM)

Full-or-part-time: 22h
Theory classes: 5h
Practical classes: 3h
Self study : 14h

6. Environmental radiological surveillance

Description:
The student will acquire the concepts of the measurements needed in national and international surveillance radiological networks. Furthermore, the interpretation of the radiological values measured will be analyzed. The students will learn in a practical way the measurement process by visiting the radiological surveillance stations and laboratories at the University. Finally, the student will learn how to decide if an area is contaminated or is exempt.

Specific objectives:
CE12, CE14

Related activities:
2.0h Radiological networks (Theory AV)
2.0h Gamma spectrometry practice (Laboratory AC)
2.0h Radiological surveillance station at Barcelona (Laboratory AV)
2.0h Radiological surveys using MARSINN (Problem DO)

Full-or-part-time: 12h
Theory classes: 2h
Practical classes: 2h
Laboratory classes: 4h
Self study : 4h

7. Dose estimation by radiological environment contamination

Description:
The students will learn how to estimate the external dose and inhalation dose due a radioactive cloud and soil deposition. Computer code Biokmod will be use for inhalation dose calculation. Exercises in class will be carried out with this code and other codes for estimating the dose rate.

Specific objectives:
CE 12, CE 14

Related activities:
1.0h Basic concepts for environmental dose estimation (Theory AV)
1.5h Model for internal dose Biokmod (Laboratory AV)
1.5h External dose rate and Internal committed Dose (Problems AV)

Full-or-part-time: 10h
Theory classes: 1h
Practical classes: 1h 30m
Laboratory classes: 1h 30m
Self study : 6h

GRADING SYSTEM

FINAL MARK: FM = 0.30*EM +0.3*PM +0.1*LM + 0.3*CM
EM: average mark of the exams
PM: average mark of the exercises
LM: average mark of the laboratory
CM: mark of the Course project

BIBLIOGRAPHY

Basic:
- Wilson, P. D. The Nuclear fuel cycle : from ore to wastes. Oxford: Oxford University Press, 1996. ISBN 0198565402.
- Bayliss, C. R; Langley, K. F. Nuclear decommissioning, waste management, and environmental site remediation [on line]. Amsterdam ; Boston: Butterworth-Heinemann, 2003 [Consultation: 20/04/2023]. Available on: https://www-sciencedirect-com.recursos.biblioteca.upc.edu/book/9780750677448/nuclear-decommissioning-waste-management-and-environmental-site-remediation. ISBN 9780750677448.
- International Atomic Energy. Generic models for use in assessing the impact of discharges of radioactive substances to environment : Safety Reports Series num. 19 [on line]. Vienna: International Atomic Energy Agency, 2001 [Consultation: 04/04/2023]. Available on: https://www-pub.iaea.org/MTCD/publications/PDF/Pub1103_scr.pdf. ISBN 9201005016.
- Simmonds, J.R.; Lawson, G.; Mayall, A. Methodology for assessing the radiological consequences of routine releases of radionuclides to the environment [on line]. Luxembourg: Office for Official Publications of the European Communities, 1995 [Consultation: 20/04/2023]. Available on: https://op.europa.eu/en/publication-detail/-/publication/1078584c-9e21-40d1-9104-82939f315f25. ISBN 9282690598.

Complementary:
- Lamarsh, John R; Baratta, Anthony J. Introduction to nuclear engineering. 3rd ed. Upper Saddle River: Prentice Hall, cop. 2001. ISBN 0201824981.
- Coll, Pere. Fundamentos de dosimetría teórica y protección radiológica. Barcelona: Edicions de la UPC, 1990. ISBN 8476530846.