Syllabus
Course Program

Reliability and Diagnostics

Specialty
141 – Electric Power Engineering, Electrical Engineering and Electromechanics

Institute
Institute of Education and Science in Power Engineering, Electronics and Electromechanics

Educational program
Electrical Power Engineering. Electric Power Stations,
Electrical Power Engineering. Energy Management and Energy-Efficient Technologies

Department
Electric Power Stations (130)

Level of education
Master's level

Course type
Special (professional), Optional

Semester
2

Language of instruction
English, Ukrainian

Lecturers and course developers

Oleksandr Lazurenko

Oleksandr,Lazurenko@khpi.edu.ua
PhD, Professor, Head of the department of electrical power plants of NTU "KhPI"

The author of more than 150 publications, including 3 training manuals and more than 25 author's certificates and patents for inventions, a member of the National Committee of the International Council for Large Electric Power Systems SIGRE Ukraine. Leading lecturer in the disciplines: "Reliability and diagnostics", "Distributed generation", "Modeling and management of electricity generation", "Research work", "Fundamentals of scientific research".
More about the lecturer on the department's website

General information

Summary

The subject of the educational discipline "Reliability and diagnostics" is the general scientific, mathematical and technical foundations of reliability in technical systems in general and power systems in particular, determination of reliability indicators of elements, devices and main equipment of power systems, as well as theoretical, algorithmic and practical foundations of technical diagnostics of power equipment, methods of determining damage to technical facilities of the electric power industry.

Course objectives and goals

Goal.
Formation in future specialists of the basis of knowledge of modern reliability theory in relation to electric power systems, as well as knowledge of modern problems of technical diagnostics of power equipment and various systems in electric power based on the analysis of mathematical models for individual elements, circuits and equipment, as well as electric power systems as a whole with in order to increase the reliability of work and resource of operation of the main equipment and power plants.
Objectives.

To know:
- general scientific, mathematical and technical foundations of reliability in technical systems in general and power systems in particular;
- basic concepts and definitions related to the theory of reliability;
basic methods of determining probabilistic reliability characteristics of technical objects and systems;
-methods of calculating and analyzing the reliability of electric power plants and systems, main schemes of power stations and substations, power supply schemes for various purposes;
- problems of increasing reliability in electric power systems and methods of their solution, criteria for increasing the reliability of power supply systems;
- basic methods of diagnostics of power equipment and basic diagnostic models; - basic technical means of technical diagnostics used at energy enterprises and energy systems in Ukraine and abroad.
To be able to:
- perform calculations of the main reliability indicators for various elements, technical objects and systems;
- draw up replacement schemes, mathematical models of equipment failures and reliability of systems without recovery and with recovery;
- choose methods and means of increasing the reliability and redundancy of equipment in electric power systems;
- choose the main electrical equipment, compare the main schemes of electrical stations and substations, their distribution devices from the point of view of reliability, perform technical and economic calculations taking into account reliability;
- perform calculations of reliability indicators of electrical power supply systems,
- use methods of diagnostics, decision-making and expert systems for optimal operation of the main equipment, evaluate the possibility of applying the main methods of technical diagnostics.

Format of classes

Lectures, practical classes, independent work, consultations, current control - modular control works. The final control is an exam.

Competencies

PC-1 Ability to apply the acquired theoretical knowledge, scientific and technical methods and appropriate software to solve scientific and technical problems and conduct scientific research in the field of electric power, electrical engineering and electromechanics.
PC-2 Ability to apply existing and develop new methods, techniques, technologies and procedures for solving engineering tasks, including in the design and operation of power engineering, electrical engineering and electromechanics facilities.
PC-4 Knowledge and understanding of laws, mechanisms and consequences of equipment failures, the ability to develop and implement measures to increase reliability, efficiency and safety in the design and operation of equipment and facilities of the electric power industry, electrical engineering and electromechanics.

Learning outcomes

PRT-1 Ability to apply the acquired theoretical knowledge, scientific and technical methods and appropriate software to solve scientific and technical problems and conduct scientific research in the field of electric power, electrical engineering and electromechanics.
PRT -2 Ability to apply existing and develop new methods, techniques, technologies and procedures for solving engineering tasks, including in the design and operation of power engineering, electrical engineering and electromechanics facilities.
PRT -4 Knowledge and understanding of laws, mechanisms and consequences of equipment failures, the ability to develop and implement measures to increase reliability, efficiency and safety in the design and operation of equipment and facilities of the electric power industry, electrical engineering and electromechanics.

Student workload

The total volume of the course is 150 hours (5 ECTS credits): lectures - 32 hours, practical classes (workshops) – 32 hours, self-study - 86 hours.

Course prerequisites

"Higher mathematics", "Fundamentals of electric power engineering", "Electrical part of stations and substations", "Electrical systems and networks", "High voltage technology", "Electromagnetic and electromechanical transient processes", "Basics of power supply and energy saving", "Operation and modes of operation of electrical equipment of power stations" knowledge is required for this course.

Features of the course, teaching and learning methods, and technologies

Lectures are conducted interactively using multimedia technologies. At workshops and laboratory classes, the skills of student work formatting, the ability to use the university educational platform and resources are practiced. Practical tasks are performed using open-source software or on the Microsoft 365 platform. Learning materials are available to students through the OneNote Class Notebook.

Program of the course

Topics of the lectures

Objectives of the discipline

The value of this discipline for other professional disciplines. The amount of educational material, types of classes and organization of training.

Content module 1. Personal computer and general-purpose software

Topic 1. INTRODUCTION AND BASICS OF RELIABILITY THEORY

The purpose and main tasks of the course. The problem of reliability of electric power equipment and electric power systems. The importance of reliability and technical diagnostics to ensure reliable and safe operation of electric power systems and energy supply to consumers. General characteristics of the mathematical apparatus. Basic definitions and concepts of reliability theory.

Topic 2. FUNDAMENTALS OF PROBABILITY AND STATISTICS.

Basic concepts and elements of the theory of probabilities as the mathematical basis of the theory of reliability. Probability Distribution Model.

Topic 3. RELIABILITY PRINCIPLES

Failure rate model. Concept of reliability of population. Mean time to failures. Reliability of complex systems. Standby system modeling, concepts of availability and dependability, reliability measurement,

Topic 4. APPLICATIONS OF SIMPLE RELIABILITY MODELS

Equipment Failure Mechanism. Availability of equipment. Oil circuit recloser (ocr) maintenance issues. Distribution pole maintenance practices. Customer service outages.

Topic 5. RELIABILITY ANALYSIS OF COMPLEX NETWORK CONFIGURATIONS

State enumeration methodologies. Network reduction methods. Bayes' theorem in reliability. Construction of fault tree diagram.

Topic 6. DESIGNING RELIABILITY INTO INDUSTRIAL AND COMMERCIAL POWER SYSTEMS

Simple radial distribution system. Reliability analysis of a primary selective system. A primary selective system to the load side. A primary selective system to the primary of the transformer. A secondary selective system. Reliability evaluation of miscellaneous system configurations.

Topic 7. ZONE BRANCH RELIABILITY METHODOLOGY

Zone branch concepts. Industrial system study. .

Topic 8. HISTORICAL RELIABILITY PERFORMANCE OF A PRACTICAL UTILITY'S ELECTRIC DISTRIBUTION SYSTEM. DETERMINISTIC CRITERIA.

Customer-oriented indices. Historical assessment. A utility corporate level analysis. Current distribution planning and design criteria. Reliability cost versus reliability benefit trade-offs in distribution system planning.

Topic 9. TECHNICAL DIAGNOSTICS OF MAIN ENERGY EQUIPMENT

Electric power production as an object of technical diagnostics. Theoretical foundations of technical diagnostics. Traditional and modern methods of diagnostics under operating voltage. Diagnostic models, methods of their arrangement and analysis. Models of the main power equipment. Consequences of failures of power equipment and RPA devices. Assessment and control of reliability based on exam results. Technical means of diagnostics of the main elements of energy production and RPA devices.

Diagnostic methods of power transformers, chromatographic analysis of gases dissolved in oil, determination of short-circuit resistance (inductance), method of partial discharges and low-voltage pulses. Probabilistic diagnostic models of diagnostic processes. Application of computer technology in solving problems of reliability and technical diagnostics, calculation databases, expert diagnostic and control systems

Topics of the workshops

Topic 1. Basic concepts and elements of the theory of probabilities as the mathematical basis of the theory of reliability.
Topic 2. Determination of quantitative reliability characteristics of non-renewable reserved maintenance and schemes. Reliability calculation of technical objects and systems that are being restored. Reliability calculation of reparable technical objects that are reserved.
Topic 3. Determination of the mathematical expectation of the average magnitude of electricity undersupply in the generation system, considering of N identical power units
Topic 4. Reliability analysis of complex network configurations.
Topic 5. Designing reliability into industrial and commercial power systems
Topic 6. Fault tree analysis
Topic 7. Zone branch concepts
Topic 8. Practical methods of diagnostics of power equipment

Topics of the laboratory classes

Self-study

Topics
Corresponds to the topics of the lecturesCoursework
Assignment according to the variant.
The term of defense of the coursework is the 16th week.

Course materials and recommended reading

Compulsory.
1. Ali A. Chowdhury, Don. O. Koval /POWER DISTRIBUTION SYSTEM RELIABILITY/ Practical Methods and Applications/ IEEE Press Editorial Board, by the Institute of Electrical and Electronics Engineers, Inc. 2009. -531p.
2. Paul Gill /Electrical power equipment maintenance and testing. - 2nd ed. p. cm. CRC Press is an imprint of Taylor & Francis Group- 2009. -962p.
3. Andrew N. O'Connor, Mohammad Modarres, Ali Mosleh/ Probability Distributions Used in Reliability Engineering. Published by the Center for Reliability Engineering University of Maryland, Maryland, USA. 2016, -205p.
Additional.
1. The Electric Power Engineering Handbook. Third Edition Edited by Leonard L. CRC Press is an imprint of Taylor & Francis Group-2012. --559p

Resources on the Internet

Assessment and grading

Criteria for assessment of student performance, and the final score structure

Final score consists of up to:
30 points for two module tests,
30 points for laboratory classes and workshops tasks,
20 points for coursework, and
20 points for final tests.

Coursework defense is mandatory.

Grading scale

Total points	National	ECTS
90–100	Excellent	A
82–89	Good	B
75–81	Good	C
64–74	Satisfactory	D
60–63	Satisfactory	E
35–59	Unsatisfactory (requires additional learning)	FX
1–34	Unsatisfactory (requires repetition of the course)	F

Norms of academic integrity and course policy

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to demonstrate discipline, good manners, kindness, honesty, and responsibility. Conflict situations should be openly discussed in academic groups with a lecturer, and if it is impossible to resolve the conflict, they should be brought to the attention of the Institute's management.
Regulatory and legal documents related to the implementation of the principles of academic integrity at NTU "KhPI" are available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Approval

Approved by	Date, signature	Head of the department Oleksandr LAZURENKO
	Date, signature	Guarantor of the educational program Oleksandr LAZURENKO