Syllabus
Course Program

Reliability and Diagnostics

Specialty
141 – Electric Power, Electrical Engineering and Electromechanics

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

Educational program
Electric Power Industry

Department
Engineering Electrophysics (135)

Level of education
Master's level

Course type
Special (professional)

Semester
2

Language of instruction
English

Lecturers and course developers

Mykyta Petrenko

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Ph. D., Associate Professor at the Engineering Electrophysics Department of NTU "KhPI".
Authored 6 publications in the domain of strong magnetic field calculations, computation of strong magnetic fields, electromagnetic forming and related areas. Lecturer on “Modelling of Electro-Physical and Electric Power Equipment and Processes”, “High Voltage Measurements”, “High Voltage Equipment”, “High Voltage Pulse Equipment”, etc.
More about the lecturer on the department's website

General information

Summary

"Reliability and Diagnostics" is a foundational course that engages students with the principles of probability theory and mathematical statistics tailored to the sphere of electrical equipment. At its core, the course centers on the intricate processes underlying the failures of electrical apparatus, especially emphasizing High Voltage (HV) equipment, an area of major significance for the participants. In the context of this course, students explore not only the general attributes of electrical equipment but are also introduced to specific considerations tied to High Voltage components, such as the degradation of insulation, electrical discharges, and unique failure modes of high voltage cables and capacitors. While the high voltage realm is given considerable focus, the curriculum ensures an inclusive overview by also addressing low voltage electrical equipment and delving into pertinent topics connected to Renewable Energy Sources (RES). As electrical equipment is pivotal in various sectors, understanding its reliability, associated failures, and diagnostic methods is indispensable for professionals in the field. This course equips learners with the knowledge and skills to compute the probability of fault-free operation of electrical equipment over its operational lifespan, granting them a competitive edge in the industry.

Course objectives and goals

The paramount objective of the "Reliability and Diagnostics" course is to endow students with a thorough understanding of the principles of probability theory and mathematical statistics as they are applied to electrical equipment's reliability and failure modes. Recognizing the significance of High Voltage equipment, a particular focus is given to exploring the intricate processes leading to the failures of such apparatus, ensuring students are well-versed in the specificities of the HV domain. Concurrently, the

course also underscores the importance of low voltage electrical devices and Renewable Energy Sources, broadening students' horizons in the electrical domain. Through a blend of rigorous theoretical discussions and hands-on practical sessions, the course aspires to nurture well-rounded professionals who are adept at both discerning the reliability of electrical equipment and leveraging diagnostic methodologies to ascertain the equipment's robustness. By the culmination of this course, learners will be poised to tackle the challenges and nuances of modern electrical systems, making valuable contributions to the electrical and energy sectors.

Format of classes

Lectures, workshops, consultations, self-study. Final control in the form of an examination.

Competencies

GC 3. The ability to apply knowledge in practical situations
GC 7. Skills of using information and communication technologies.
GC 8. The ability to learn and master modern knowledge.
GC 9. Ability to search, process and analyze information from various sources
PC 3. Ability to use basic knowledge of general physics, higher mathematics, theoretical foundations of electrical engineering and electrical materials for solving practical problems in the field of electric power engineering, electrical engineering and electromechanics.
PC 4. Ability to use professional knowledge in the basics of electric power: electrical part of stations and substations, electrical systems and networks, relay protection and automatics of power systems and high voltage equipment for solving practical problems in the field of electric power engineering, electrical engineering and electromechanics.
PC 12. Ability to study and analyze scientific and technical information in the field of electric power engineering, electrical engineering and electromechanics.
PC 20. Receiving and using professional knowledge and understanding related to the processes of electrophysical highvoltage installations for scientific research and industrial technologies, as well as renewable energy installations.

Learning outcomes

PRT 2. Discuss professional topics
PRT 18. To evaluate the parameters of the electrical, electrical and electromechanical equipment and related complexes and systems work and to develop measures to increase their energy efficiency and reliability.
PRT 19. Solving professional tasks in the design, installation and operation of electric power, electrical engineering, electromechanical complexes and systems.
PRT 40. Know and understand the processes of operation of electrophysical high-voltage installations for scientific research and industrial technologies, as well as renewable energy installations.

Student workload

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

Course prerequisites

Higher Mathematics, Physics

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

Lectures employ modern multimedia tools to enhance the learning experience. Workshops are structured around a mix of student preparatory self-study and collaborative team activities. Experiential learning is also an integral part of the coursework, allowing students to learn from real-world scenarios. Knowledge and skills cultivated during practical sessions are further reinforced as students tackle individual computational tasks.

Program of the course

Topics of the lectures

Topic 1. The Role of Reliability and Diagnostics in High Voltage and Power Engineering
Exploring the significance of reliable design and diagnostic techniques in maintaining system integrity and performance in electrical power applications.
Topic 2. Fundamentals of Probability and Statistics in High Voltage Applications
An introduction to the key statistical methods and probability theories essential for analyzing and predicting the behavior of high voltage systems.
Topic 3. Reliability Metrics and Their Significance
A comprehensive look at various reliability metrics, their calculation, and how they are used to gauge the dependability of electrical components.
Topic 4. Characterization of Insulation Failures in Electrical Components
Examining the common types of insulation failures, their causes, and the impact they have on the performance of electrical systems.
Topic 5. Electric Aging Theories and Stressed Volume Concept
Understanding the mechanisms of electrical aging and how stressed volume theory is applied to predict insulation life expectancy.
Topic 6. Common Modes of Failure in High Voltage Insulation Systems
An analysis of typical failure modes in insulation systems, including the factors that contribute to their occurrence.
Topic 7. Influential Factors on the Life Span of Impulse Capacitors
Investigating the external and internal factors that affect the durability and functional lifespan of impulse capacitors in high voltage systems.
Topic 8. Aging Mechanisms in Insulation Materials
Delving into the physical and chemical processes that lead to the degradation of insulation materials over time.
Topic 9. Distribution Laws of Insulation Failures: Theory and Application
A study of various statistical distribution laws, such as Weibull and exponential, and their application in modeling insulation failures.
Topic 10. Empirical and Theoretical Functions in Reliability Engineering
Comparing empirical data with theoretical models to understand and predict the reliability of electrical components.
Topic 11. Analysis of Insulation Test Results for Reliability Assessment
Techniques for interpreting insulation test results and using this data to evaluate the reliability of high voltage systems.
Topic 12. Structural Reliability and Calculation Schemes in Electrical Systems
Understanding the structural aspects of reliability in electrical systems and the methodologies used to calculate it.
Topic 13. Reliability Testing Methods and Approaches
Overview of various reliability testing methods, including sequential analysis and single sampling, and their application in the field.
Topic 14. Residual Life Analysis of Power Capacitors and Their Protective Measures
Methods for estimating the remaining useful life of power capacitors and strategies for prolonging their service life through protective measures.
Topic 15. Diagnostics of High Voltage Insulation: Non-Destructive and Destructive Techniques
An exploration of both non-destructive and destructive diagnostic techniques used to assess the condition of high voltage insulation.
Topic 16. Reliability Challenges in Renewable Energy Systems and Traditional Power Engineering
Addressing the unique reliability challenges faced by renewable energy systems, as well as those common in traditional power engineering, and strategies to mitigate them.

Topics of the workshops

Topic 1. Practical Applications of Reliability and Diagnostics in Electrical Engineering
Hands-on experience with the tools and methods used in the field to ensure the reliability and proper diagnostics of electrical systems.

Topic 2. Statistical Data Analysis in Electrical Engineering
Engaging in real-world data analysis to apply statistical concepts and probability theories to high voltage engineering problems.
Topic 3. Computing and Interpreting Reliability Metrics
Utilizing software tools to calculate various reliability metrics and interpret their significance in the context of electrical components.
Topic 4. Diagnosing Insulation Failures: Techniques and Case Studies
A workshop centered around identifying and diagnosing insulation failures through a series of case studies and practical examples.
Topic 5. Modeling Electrical Aging and Life Prediction
Applying stressed volume concept and aging theories to model and predict the lifespan of electrical insulation materials.
Topic 6. Investigating Failure Modes in High Voltage Insulation
An interactive session exploring the common failure modes in high voltage insulation through experimentation and analysis.
Topic 7. Assessing Influences on Impulse Capacitor Lifespan
Conducting experiments and simulations to understand the effects of various factors on the lifespan of impulse capacitors.
Topic 8. Studying Aging Mechanisms in Insulation Materials
A hands-on approach to examining the aging processes in different insulation materials used in high voltage applications.
Topic 9. Applying Distribution Laws to Model Insulation Failures
Working with statistical software to apply distribution laws in predicting and modeling insulation failures.
Topic 10. Comparing Empirical and Theoretical Reliability Functions
Using real-world data to compare empirical results with theoretical reliability models and functions.
Topic 11. Analysis and Interpretation of Insulation Test Data
Practical exercises in analyzing insulation test data to assess the condition and reliability of electrical components.
Topic 12. Designing Structural Reliability into Electrical Systems
Interactive sessions focused on designing and calculating the structural reliability of various electrical system configurations.
Topic 13. Conducting and Analyzing Reliability Tests
Engaging in hands-on reliability testing using different methods and analyzing the results for practical insights.
Topic 14. Estimating and Extending the Life of Power Capacitors
Techniques for assessing the residual life of power capacitors and implementing protective measures to extend their service life.
Topic 15. Diagnostic Techniques for High Voltage Insulation: A Practical Approach
Applying both non-destructive and destructive diagnostic techniques to real-world high voltage insulation scenarios.
Topic 16. Addressing Renewable Energy Reliability Challenges through Workshops
Interactive sessions focusing on identifying and solving reliability issues specific to renewable energy sources, alongside traditional power engineering challenges.

Topics of the laboratory classes

Self-study

In this course, students will analyze case studies on high voltage engineering, enhancing their understanding through practical application. They'll perform computational exercises to model high voltage systems and engage in a research project examining its role in their country's energy sector, with a focus on renewable sources.
Supplemental resources will support deeper exploration, and a final essay will encapsulate their insights. This self-study approach not only broadens knowledge but also hones practical skills in high voltage engineering.

Course materials and recommended reading

1. O'Connor, Patrick, and Andre Kleyner. Practical reliability engineering. John Wiley & Sons, 2012.
2. Bazovsky, Igor. Reliability theory and practice. Courier Corporation, 2004.
3. Myers, Raymond H., et al. Generalized linear models: with applications in engineering and the sciences. John Wiley & Sons, 2012.
4.Rausand, Marvin, and Arnljot Hoyland. System reliability theory: models, statistical methods, and applications. Vol. 396. John Wiley & Sons, 2003.

Assessment and grading

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

The final score for this course is calculated based on a combination of evaluations from final exam, workshop achievements, and the execution of individual assignments.
1. Exam.
Students can earn up to 40 points from the final exam. The exam evaluate the student's comprehension and knowledge retention from the lecture material.
2. Workshop Assignments.
Engaging and participating in workshops, including quizzes and tasks, can earn students up to 30 points.
3. Individual Assignments.
For the completion of individual assignments students can receive up to 30 points.

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 2023	Head of the department Serhii MOSTOVYI
	Date, signature 2023	Guarantor of the educational program Halyna OMELIANENKO