NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF PETROLEUM AND PETROCHEMICAL ENGINEERING
PETROLEUM ENGINEERING PROGRAM

PQ324 – CORROSION

I. GENERAL INFORMATION

CODE	**:**	PQ324 Corrosion
SEMESTER	**:**	8-10
CREDITS	**:**	3
HOURS PER WEEK	**:**	5 (Theory–Practice)
PREREQUISITES	**:**	PQ223 Physical Chemistry
CONDITION	**:**	Elective

II. COURSE DESCRIPTION

The course prepares students in the understanding of corrosion phenomena, analyzing its characteristics, as well as its causes, measurement, and control its propagation speed in different types of materials. Students analyze chemical and electrochemical corrosion, polarization curves, methods for protection and correction against corrosion, and selection of materials according to the corrosion conditions. At the end of the course, students submit and defend a project on a particular corrosion problem.

III. COURSE OUTCOMES

At the end of the course, students:

1. Organize samples of materials and carry out corrosion analysis according to DIM, ASTM, API standards and norms.
2. Explain the characteristics of products formed by materials corrosion and degradation.
3. Understand and apply the mechanisms of corrosion, and evaluate the damage and effects of corrosion depending on the environment and working conditions.
4. Interpret polarization curves in stationary and non-stationary systems and use specialized software to evaluate the mechanisms of corrosion.
5. Build kinetic models and propose strategies for preventing the corrosion of materials.
6. Select materials for the mining-metallurgical industry.

IV. LEARNING UNITS

1. REVIEW OF METALLURGY AND MATERIALS SCIENCE

Materials crystallization structure / Metallography and macrography / Impact of alloy elements in materials / Heating treatments / Materials forming / Mechanical tests / Thermodynamic equilibrium diagrams / Electrochemical kinetics.

2. CHEMICAL CORROSION

Oxide thickness / Thick layers and transport / Free enthalpy of chemical reactions / Ellingham diagrams / Kinetic laws of high temperature corrosion / Chemical corrosion process in ferrous and non-ferrous materials / Oxides stoichiometric structure / Oxides types, P and N / Alloys design / Effect of alloy elements / Corrosion in molten salts.

3. ELECTROCHEMICAL CORROSION

Fundamentals / Basic laws in electrochemistry / Aqueous solutions / Electrode potential. / Double electrical layer / Nernst equation / Reference electrodes / Pourbaix's diagrams / Electrodes kinetics / Electrode polarization: charge transference overpotential, Butler-Volmer equation, Tafel equation / Diffusion overpotential / Mixt overpotential / Anodic and cathodic reactions / Anodic and cathodic polarization curves / Mixt potential theory.

4. POLARIZATION CURVES

Basics of electrochemical measurements of ferrous and non-ferrous materials in stationary and non-stationary states / Polarization curves in stationary state, corrosion potential, polarization resistance Rp, Tafel, Potential-dynamics and Galvanic-dynamics. / Polarization curves in non-stationary state, electrochemical impedance spectroscopy (EIS), cyclic voltammetry / Polarization curves of rotatory electrode kinetics.

5. PROTECTION AND CORRECTION AGAINST CORROSION

Basics of surface technology / Electrolytic coating: copper plated, nickel plated, hard chrome / Galvanization: electro-deposition, in-hot immersion / Anodizing / Plasma coating / Sputtering.

6. MATERIALS SELECTION

Effect of non-proper materials selection / Methodology for materials selection / Mechanical, physical and chemical properties of materials / Quality norms of materials: ASTM, DIM and API / Software for materials selection according to environment and working conditions.

V. PRACTICAL WORK

Session 1: High temperatures kinetics of ferrous and non-ferrous materials
Session 2: Kinetics of agitation
Session 3: Electrolytic coatings
Session 4: Electrochemical measurements of ferrous and non-ferrous materials in stationary and non-stationary states.

VI. METHODOLOGY

The course takes place in theory, practice and laboratory sessions. In theory, faculty presents and analyze concepts and methods. In practice sessions diverse problems related to measure and control of corrosion speed are solved and analyzed. In laboratory sessions, students perform experimental tests and use specialized software for analyzing electrochemical measurement techniques, electrochemical impedance spectroscopy (EIS) and cyclic voltammetry. Student's active participation is promoted. After each laboratory experience, students submit a report describing procedures and summarizing results and conclusions. Student's active participation is promoted.

VII. GRADING FORMULA

The Final Grade PF is calculated as follow:

PF = (EP + EF + PL) / 3

EP: Mid-term Exam EF: Final Exam
PP: Average of Practical Laboratory Works.

VIII. BIBLIOGRAPHY

1. ASM HANDBOOK.
   Corrosion Fundamentals, Testing and Protection, Volume 13, USA, 2006.
2. GONZALES FERNANDEZ, Jose.
   Corrosion control, Study and Measurement by Electrochemical Techniques, Ed. Grafipren S.A. Madrid, Spain, 2010.