UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2019/2020
MASTER'S DEGREE (MSC)	AEROSPACE ENGINEERING
SUBJECT	CORROSION AND PROTECTION OF AEROSPACE MATERIALS
TYPE OF EDUCATIONAL ACTIVITY	C
AMBIT	20907-Attività formative affini o integrative
CODE	18053
SCIENTIFIC SECTOR(S)	ING-IND/23
HEAD PROFESSOR(S)	DI FRANCO FRANCESCO Professore Associato Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	1
TERM (SEMESTER)	2° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**DI FRANCO FRANCESCO** Monday 13:00 14:00 Studio personale. Wednesday 13:00 14:00 Studio personale. Friday 13:00 14:00 Studio personale.

DOCENTE: Prof. FRANCESCO DI FRANCO

PREREQUISITES	General and Inorganic Chemistry, basic electricity with an emphasis on Ohms Law
LEARNING OUTCOMES	Knowledge and understanding At the end of the course student is expected to have a deep understanding of the mechanism of corrosion processes and on their nature as a function of the environmental physico-chemical conditions. Student will be aware on the synergistic effect of stress and corrosion in materials degradation and failure. He/she is expected to know the corrosion protection methods and strategies and to isolate the critical issues responsible of material degradation. Student will learn about corrosion protection and prevention in the aerospace industry, necessary for correct aircraft design and maintenance Applying knowledge and understanding Student is expected to know corrosion mechanism and morphology of the metallic material in different environments. Thanks to this fundamental knowledge he/she will be able to understand causes of the corrosion processes with a special focus on the phenomena involving metals and alloys usually employed in the aerospace industry, being able to select the most appropriate material according to the environmental conditions. Making judments Starting from knowledge of the theoretical aspects of the corrosion processes as well as from the laboratory experiences the student is expected to be able to match the right material with the environment where the latter is supposed to work, and he/she will regulate the maintenance of aircraft, in order to ensure safe and correct functioning during flight. Communication Student is expected to be able to work autonomously and collaborate with other team members involved in the same project (design and/or maintenance). Learning skills Following a deep understanding of the theoretical aspects and a after laboratory experience, student is expected to be able to seek advice from technical regulations, technical manuals, scientific literature updating frequently his/her knowledge.
ASSESSMENT METHODS	The assessment will be performed through an oral exam with questions focused on three main subjects: thermodynamic aspects of corrosion processes, kinetic aspects of corrosion processes and possible problems/warning using metals and/or alloys typical of aerospace industry as a function of the hosting environment conditions. The student must support the answers qualitatively and quantitatively taking advantage of the technical tools provided by the evaluation committee (Pourbaix Diagram, national and international prescriptions, etc.). The student will also discuss a case study (selected among three options) of practical relevance in the field of building engineering. The interview is aimed at determining the student abilities to process the knowledge gained by using them to solve problems and the ability to express the teaching content using a technically correct language. Special attention will be paid to the correct use of physical dimensions (current, current density, corrosion rate, etc.). The vote is expressed in thirtieths with possible praise. A maximum of 24/30 will be attributed according to the student reply on the proposed questions, while the remaining 6/30 and praise will be attributed according to the discussion on the case study. In order to get the minimum score for a positive evaluation (18/30), the student must know the general aspects of the course content, and must identify the main factors affecting the behaviour of metals and/or alloys as a function of the environmental conditions. His/her command of technical language must be sufficient to clearly discuss with the evaluation committee about corrosion issues in aerospace industry. Higher score will be attributed according to their ability in applying knowledge and skills learned in this course to practical and technical problems, according to what extent students are aware of the steps they go through in solving problems and how well can they explain their problem-solving steps.
EDUCATIONAL OBJECTIVES	The aim of the course is to provide basic concepts of corrosion processes and the tools for a correct selection of the materials, of the protection and prevention methods to control and limit the damages and failure in aerospace industry.
TEACHING METHODS	Frontal lectures, Laboratory and Demonstration Sessions, Laboratory Practice Sessions
SUGGESTED BIBLIOGRAPHY	Pietro Pedeferri, Corrosione e protezione dei materiali metallici. Vol. I e Vol. II, polipress, 2007, Milano Italia. Corrosion Control in the Aerospace Industry, Edited by Samuel Benavides, US Coast Guard, USA, 2009. Lectures notes and powerpoint presentations.

SYLLABUS

Hrs	Frontal teaching
4	Introduction. General aspects of corrosion processes. Mechanical and physico-chemical properties of materials. Direct and indirect corrosion damages.
5	Wet and dry corrosion. Electrochemical mechanism of corrosion. Corrosion reactions: anodic and cathodic half cell reactions. Faraday's law. Thermodynamics of corrosion. Standard potential, Nernst Equation and Pourbaix diagrams.
5	Kinetic of corrosion. Cathodic and anodic overvoltage.Charge transfer and mass transfer control. Passivation conditions. Evans diagrams. Influence of Metal on corrosion processes.
8	Corrosion attack morphology: generalized corrosion, galvanic coupling, pitting corrosion, crevice corrosion, interference corrosion, selective dissolution, intergranular corrosion, turbulence corrosion, erosion corrosion, impingement corrosion, stress corrosion cracking, fatigue corrosion, hydrogen embrittlement, microbial corrosion. CO2 and H2S induced corrosion.
5	Al alloys. Effects of corrosion of structural integrity of aircrafts. Effect of corrosion processes on mechanical properties of Al light alloys. Impact of corrosion damages and cost in the aerospace industry.
4	Monitoring, evaluation and prevention of corrosion processes: non destructive techniques for corrosion evaluation in the aerospace industry. Modeling of corrosion processes, of stress corrosion and fatigue corrosion of structure for aerospace applications.
7	Protection against corrosion: coatings and surface treatments. Anodizing of aluminium and magnesium alloys. Inhibitors and inhibitors embedded coatings. Primer. Conversion coatings and chromate free conversion coatings. Influence of microstructure on corrosion resistance of Al alloys. Corrosion resistance of welded region: postwelding treatments. Coating removal.
2	Corrosion tests: corrosion rate estimate in laboratory and in real systems (Salt Spray Test, Adhesion test, etc).
2	Design and selection of material: data base consulting, smart systems and regulations. Economic evaluation and reliability assessment (Life Cycle Cost, Decision analysis)

Hrs	Practice
2	Pourbaix diagrams from thermodynamics data and their use in corrosion studies.
2	Experimental determination of corrosion potential and corrosion rate. Polarization resistance measurement d.c. and a.c. methods.Corrosion protection and prevention: noble materials, passive films, coating, cathodic protection, inhibitors.
2	Inspection techniques on structure and non destructive techniques. Analysis of corrosion damaged materials. Monitoring of on going corrosion processes.
2	Cathodic protection: potential and current density for cathodic protection. Coatings. Laboratory test on cathodic protection, coatings fabrication and characterization by eletrochemical and structural techniques).
2	Anodizing of Al and Mg alloys. Test of corrosion resistance of anodic oxides on Al alloys and Mg alloys. Corrosion resistance tests on Ti and Ti alloys, and on carbon and stainless steel.
2	Corrosion products identification by X-ray diffraction and Raman Spectroscopy. Analysis of the attack morphology by scanning electron microscopy.