SOUTHEAST COMMUNITY COLLEGE
CONSTRUCTION, MANUFACTURING AND TECHNOLOGY DIVISION
Energy Generation Operations Technology Program
Revision Date: August 21, 2023

I. CATALOG DESCRIPTION

Course Number:	ENER2220
Course Title:	Reactor Plant Materials
Prerequisite(s):	ENER2102 and ENER2530
Catalog Description:	This course provides students with an understanding of the various materials used in the operation of a nuclear power plant. Topics include phase balance of materials, mechanical properties and behavior of materials, environmental effects on materials, and nuclear-specific topics such as fuel pellets, fuel rod cladding, control rods, radiation effects on materials, enrichment of radioactive isotopes and fuel pellet fabrication.
Credit Hours:	2
Class Hours:	30
Lab Hours:	0
Total Contact Hours:	30

II. COURSE OBJECTIVES: *Course will:*

- **A.** Explain the basic structure of metals and how those structures are affected by various processes and irradiation.
- **B.** Explain commonly used materials and their characteristics.
- **C.** Explain thermal stress and thermal shock effects on a system.
- **D.** Explain brittle fracture characteristics, mechanisms and temperature effects to reactor plant materials.
- **E.** Introduce the chemical interaction of general and specific types of corrosion.
- **F.** Describe the chemical measures taken to retard the corrosion.
- **G.** Introduce reactor vessel components relating to the fuel and control mechanisms.

III. STUDENT LEARNING OUTCOMES AND GENERAL EDUCATION LEARNING OUTCOMES:

- **A.** Student Learning Outcomes: *Student will be able to:*
  1. Discuss basic material properties
  2. Explain and define the various negative effects of thermal shock (stress) to a reactor system.
  3. Discuss operational limitations used to prevent brittle fracture
  4. Explain the characteristics of, and control methods for corrosion types common in a nuclear reactor plan.
  5. Explain the effects of radiation exposure on various plant materials
- **B.** General Education Learning Outcomes
  - **1.** GELO #3: Critical Thinking & Problem Solving
    Outcome 1: Collect, identify, interpret and analyze data.

IV. CONTENT/TOPICAL OUTLINE

- **A.** Structure of Metals
  - **1.** Atomic bonding
  - **2.** Common lattice types
  - **3.** Grain structure and boundary
  - **4.** Polymorphism

5. Alloys

B. Properties of Metals
- **1.** Stress
- **2.** Strain
- **3.** Young's Modulus
  - **a.** Hooke's Law
  - **b.** Young's Modulus (Elastic Modulus)
- **4.** Stress-Strain relationship
- **5.** Physical properties
- **6.** Working of metals
- **7.** Corrosion
  - **a.** Pit and crevice
  - **b.** Denting
  - **c.** Galvanic
  - **d.** Chloride stress
  - **e.** Caustic stress
  - **f.** Stress corrosion cracking and inter-granular corrosion stress corrosion cracking
  - **g.** Microbiologic induced corrosion
- **8.** Hydrogen embrittlement
  - **a.** Zirconium
  - **b.** Stainless Steel
  - **c.** Benefits of hydrogen

C. Effects of contaminants on corrosion
- **1.** Fatigue failure/work hardening
- **2.** Vibration induced cracking

D. Thermal Stress
- **1.** Thermal shock
- **2.** Pressurized thermal shock
- **3.** Locations of concern

E. Fracture Mechanics
- **1.** Fracture Mechanisms
- **2.** Minimum Pressure Limitations
- **3.** Stress Control

F. Brittle Fracture
- **1.** Brittle fracture mechanism
- **2.** Minimum Pressurization-Temperature (MPT) curves
- **3.** Heat-up and Cool-down rate limitations

G. Plant Materials
- **1.** Selecting materials
- **2.** Fuel materials
- **3.** Cladding and reflectors
- **4.** Control materials
- **5.** Shielding materials
- **6.** Nuclear reactor core problems
- **7.** Plant material problems
- **8.** Atomic displacement due to irradiation
- **9.** Thermal and displacement spikes due to irradiation
- **10.** Effect due to neutron capture
- **11.** Radiation effects in organic compounds
- **12.** Reactor use of aluminum

H. Reactor Water Chemistry
- **1.** Interaction of radiation (Synthesis)
- **2.** Chemistry parameters

I. Principles of Water Treatment
- **1.** Water treatment processes
- **2.** Dissolved gases, suspended solids, and pH control
- **3.** Water purity

J. Core Materials
- **1.** Uranium enrichment
- **2.** Fuel pellet construction
- **3.** Fuel rod construction
- **4.** Control Rod Construction

K. Radiation effects
- **1.** Neutron Irradiation
- **2.** Gamma Irradiation

V. INSTRUCTIONAL MATERIALS

A. Required Text(s): None

B. Other Resources: Internet and *DOE Fundamentals Handbooks: Material Science I & II* and *Chemistry I & II* (Provided by the Instructor)

C. Outside Reading/Research required: Internet Research assignments

D. Supplies: None

VI. METHODS OF PRESENTATION/INSTRUCTION

A. Methods of presentation typically include a combination of the following:
- **1.** Hybrid

VII. METHODS OF EVALUATION

A. Methods of evaluation, although determined by the individual instructor, traditionally includes a combination of the following:
- **1.** Class participation
- **2.** Regular assignments
- **3.** Written exams and/or quizzes
- **4.** Performance and observational assessments

VIII. SPECIFIC COURSE REQUIREMENTS

A. A minimum grade of "C" or 70% is required to receive credit for this course.

B. A minimum grade of "B" or 80% is required to achieve the NUCP certificate, in accordance with ACAD 08-006, Revision 1, dated October 2016.

C. Cheating within the Construction and Electronic Occupations Division: Any violation of academic integrity on assignments, quizzes, or tests will result in a grade of 0 on that assignment, quiz, or test. A second violation in any course after the initial infraction will result in a grade of F for that course. Any additional violations while in the program will result in a suspension from the program. For additional information, refer to the *Academic Integrity* pamphlet available from Student Services.

D. Credit by Examination: Credit for the course CANNOT be earned through Credit by Examination.