Nuclear Plant Materials
Outline of Instruction

Course Information

Organization	Monroe County Community College, Applied Science and Engineering Technology
Developers	R.S. Chandel
Development Date	10/12/2008
Revised Date	1/5/2009
Course Number	MATL-121
Instructional Level	AAS
Potential Hours of Instruction	60
Total Credits	3

Description
This is an introductory course on materials for nuclear power plants. The major topics include the atomic structures, phase diagrams, types and classification of alloys, mechanical properties with emphasis on the brittle fracture, effect of environment on the degradation of properties and how to evaluate the safe working stresses. Plant material problems and selection of appropriate materials for various components will also be discussed. Laboratory experience will be gained in mechanical testing, microscopy, corrosion testing, etc.

Major Units

I Introduction (2 hours)

A. Materials science and engineering
B. Classification of materials
C. Materials needs of power plants

II Atomic Structure, Bonding and Radioactivity (3 hours)

A. Basics of atomic structure and atomic configuration
B. Atomic bonding in solids and bonding forces
C. Isotopes, radioactivity and physics of nuclear fission

III Crystal Structures, Defects and Diffusion (4 hours)

A. Fundamental concepts of crystal structures
B. Crystal structures and crystal systems
C. Polymorphism and allotropy
D. Crystalline materials and amorphous materials
E. Crystal defects
F. Diffusion in metals and its effects
G. Grain size and grain refining

IV Phase Diagram (4 hours)

A. Solubility limits
B. Phases and microstructures in binary systems
C. Study of important equilibrium diagrams
D. Interpretation of phase diagrams

V Strengthening Mechanisms and Alloys (4 hours)

A. Solid-solution strengthening
B. Strengthening of metals by grain size reduction
C. Strain and age hardening
D. Strengthening by phase transformations
E. Characteristics of alloys
F. Composition and properties of common engineering alloys

VI Mechanical Properties of Metal (5 hours)

A. Meaning of hardness and its measurement
B. Elastic and plastic behavior of metal
C. YS, UTS, ductility and their measurement
D. Fatigue and creep properties
E. Factors affecting mechanical properties

VII Brittle Fracture (5 hours)

A. Ductile and brittle failure
B. Ductile to brittle transition, NDT and its measurement
C. Factors promoting brittle fracture
D. Stress-temperature curves
E. Brittle Fracture Prevention Limit curves.
F. Minimum Pressurization-Temperature (MPT) curves

VIII Corrosion and Hydrogen Embrittlement (3 hours)

A. Mechanism and forms of corrosion
B. Corrosion rates, their prediction and control
C. Hydrogen embrittlement concepts and effects on common power plant materials

IX Material Compatibility (3 hours)

A. Nuclear power plant environment and material concerns
B. Hydrogen solubility and permeability in metals
C. Hydriding and nonhydriding metals
D. Graphite, glasses, ceramics, plastics, elastomers, and oils

X Thermal Effects (4 hours)

A. Thermal stresses and strains
B. Concept of Pressurized Thermal Shock (PTS)
C. Evaluating effects of PTS during heatup and cooldown.
D. Limiting heatup and cooldown rates
E. Soak times

XI Plant Materials and Their Selection (4 hours)

A. Fuel materials
B. Cladding and reflector materials
C. Control materials
D. Shielding materials

XII Plant Materials Problems (4 hours)

A. Nuclear reactor core problems
B. Fatigue failure, strain hardening and creep failure
C. Atomic displacement due to irradiation
D. Thermal and displacement spikes
E. Neutron capture effects

Lab Work and Lab Reports
There will be 7-8 Lab experiments, each lasting one session (2 hrs). For this purpose, students will form the Lab Groups comprising 3-4 students. Although students will work in groups, the Lab reports will be individually. The grading system for each Lab rework will be described in the handouts.

Types of Instruction

Instruction Type	Contact Hours	Credits
Classroom Presentation	60	3

Textbooks

William F. Smith. *Reactor Plant Materials" ISBN: 0-390-48957-3., McGraw-Hill.* McGraw-Hills 2004.

Learner Supplies

None.

Prerequisites

None

Exit Learning Outcomes

General Education Outcomes

A. Demonstrate an understanding of the process of scientific inquiry
B. Communicate information in writing using the rules of standard American English

Course Outcomes

1. **Describe the bonding and patterns that affect the structure of a metal**
2. **Describe the formation of alloys systems and means to manipulate their constituents.**
3. **Describe how changes in stress, strain, and physical and chemical properties affect the materials used in a reactor plant.**
4. **Describe the importance of minimizing thermal shock.**
5. **Explain the importance of controlling heatup and cooldown rates of the primary coolant system.**
6. **Describe the considerations commonly used when selecting material for use in a reactor plant.**