NUC K210 Nuclear Instruments and Control

☒ Required ☐ Elective

Catalog Description: The study of the underlying electrical, mechanical, physical, and chemical principles by which the instrumentation and modern PWR (pressurized water reactor) and BWR (boiling water reactor) systems control the safe generation of nuclear-based power. Emphasis is placed on the full understanding of the nuclear fission process and the interactions of the numerous sybsystems required monitoring and controlling this important energy technology.

Prerequisites: EET 2104/5;NUC 110/111,100,117,250

Textbook(s) or other materials: Introduction to Nuclear Systems - Northeast Utilities Text; Basic Nuclear Engineering, Foster and Wright, 4th Edition; Basic Radiation Protection, Gollnick, 4th Edition

Course learning outcomes/Expected performance criteria:

The student will:

Develop a working knowledge of nuclear radiation detectors and their performance within radiation detection systems as employed in commercial nuclear power reactors.

Study reactor pressure and differential pressure monitoring systems which measure pressurizer level, coolant flow, and pressurizer pressure.

Understand the effects of temperature monitoring systems, including thermocouples and resistance detectors, as impact reactor operational safeguards.

Develop a thorough understanding of control rod drive systems, including a scram function, as control reactivity and emergency control functions.

Study the various interlocks, trips and time delay responses that function to permit safe operation of a commercial nuclear reactor.

Understand the interworking relationships of all instrumentation and control sub-systems as they safeguard reactor operation and their importance in overall reactor safety.

Topics covered:

COURSE TOPICS/CONTENT	HOURS
I Nuclear Radiation Detectors and Radiation Detection Systems Including Reactor Power Monitoring a. Nuclear Detector Theory b. Typical Reactor Power Monitoring Systems c. Typical Radiation Monitoring Systems	6
II Nuclear Reactor Pressure and Differential Pressure Monitoring Systems a. Typical Transmitters b. Pressure Measurement c. D/P Measurement d. Typical Loops 1. Pressurizer level	6

2. Reactor coolant flow
3. Pressurizer pressure

III Reactor Temperature Monitoring Systems 6
- a. Resistance temperature detectors, RTD
- b. Thermocouples TC
- c. Typical loops
  1. Th - Hot leg temperature
  2. Tc - Cold leg temperature
  3. Tave - Average temperature
  4. In core TC's

IV. Control Rod Drive Systems 6
- a. Mechanism Types
- b. Typical Loops and Mechanisms
  1. Typical drive system
  2. Scram function

V. Reactor Protection Systems 6
- a. Principles
  1. Interlocks
     a. typical loops
  2. Trips/scrams
     a. typical system
     b. redundant coincident protection system
  3. Time response requirements

TOTAL HOURS: 30

Class/Lab schedule: 2 lecture sessions per week

Relationship of course to Criterion 5 and Program Outcomes:

Prepared by: James R. Sherrard

NUC K211 Nuclear Instruments and Control Lab

☒ Required ☐ Elective

Catalog Description: These laboratory exercises transfer acquired electrical, mechanical, physical, and chemical technology gained in earlier courses in hands-on applications to 15 selected nuclear instrument controlled subsystems. Emphasis is placed on the full understanding of the detection capabilities and subsequent safe nuclear system control

Prerequisites: EET K142/143, NUC K100, NUC K110/111, NUC K117, NUC K250

Textbook(s) or other materials: Introduction to Nuclear Systems - Northeast Utilities Text, Basic Nuclear Engineering, Foster and Wright, 4th Edition, Basic Radiation Protection, Gollnick, 4th Edition

Course learning outcomes/Expected performance criteria:

The student will be able to:

Identify all instrumentation and control sub-systems that measure PWR and BWR operational performance and demonstrate the interrelationships between the various sub-systems.

Perform laboratory experiments on the following sub-systems:
a) radiation detection
b) pressure and differential pressure
c) temperature
d) rod control and position indication
e) interlock, scram, trip, and time delay protection equipment

Detailed laboratory experiments will evaluate the individual performance of each sub-system as a separate safety system, and the redundancy of mutually protective sub-systems interrelating to achieve overall reactor operational safety.

Specific laboratory experiments will emphasize PWR system performance with BWR systems demonstrated when significant operational differences exist.

Topics covered:

	HOURS
I. Radiation Detection/NIS	6
a) Using a check source to calculate the effects of distance and shielding	
b) Tour a Rx simulator gather information about the nuclear instrument system	
II. Pressure and D/P	6
a) Connect and determine the accuracy of a simple pressure control loop	
b) Calibrate a pressure/dp transmitter	
c) Tour a reactor simulator and gather information on various pressure and D/P loops.	
III. Temperature	6
a) Measure the resistance of an RTD at two different temperatures plot the transfer curve for the RTD.	
b) Measure the output of a thermocouple at two different temperatures and determine the transfer curve.	

c) Tour a reactor simulator and gather information about various temperature indicating equipment.

IV. Rod Control and Position Indication 6
   a) Tour a Rx simulator gather information about the reactor rod control and position indication system.

V. Rx Protection System 6
   a) Design a block diagram Reactor Protection system with the following properties:
      * redundant coincident trip logic
      * hi SUR trip when less then 10% Rx power 1/2
      * Rx low pressure trip 2/3
      * Rx high pressure trip 2/3
      * other
   b) Perform a time response measurement for an instrument loop.

TOTAL HOURS: 30

Class/Lab schedule: One lab session per week

Relationship of course to Criterion 5 and Program Outcomes:

Prepared by: James R. Sherrard