

# NUCLEAR REACTORS AND SAFETY- AN INTRODUCTION - Video course

## COURSE OUTLINE

Nuclear safety is today an important topic of discussions and debate, whenever we talk about Nuclear Energy. The concerns have arisen after the accidents at Chernobyl in Russia and Fukushima in Japan. Subsequent to the bombings of Hiroshima and Nagasaki, the approach in all nuclear facilities right from their inception, has been to minimize the chance of any mal-operation, minimize the consequences of any event should it occur and containing any radiation from the plant, referred to as the Defence in Depth approach. Safety regulation under the International atomic Energy Agency has been the hallmark in the Nuclear arena. New designs like GEN IV utilize passive systems for shutting down and heat removal, making such designs more immune to failures in active systems. The follow up of the survivors of the Hiroshima Nagasaki bombings and their future off-springs have shown that a maximum of 2 cancers could only be attributed to the bombs. To appreciate the nuclear power and its benefits to mankind, one needs to understand the different safety approaches from site selection to operation of Nuclear reactors. It is also necessary to look at the regulatory approaches adopted, which assures safety. This course is expected to provide information to the graduate and post graduate students undergoing courses in nuclear engineering in IITs and other Universities on all aspects of nuclear safety.

## COURSE DETAIL

Module No	TOPIC	Lectures
1	Introduction	2
	Energy sources, Nuclear Power Production, medical and Societal applications of radiation	
	Nuclear fuel cycle	



# NPTEL

<http://nptel.ac.in>

## Physics

### Pre-requisites:

The reader must have a general picture about the various energy sources and their applications

### Additional Reading:

- [IAEA.org](http://IAEA.org)
- [Wano.org](http://Wano.org)
- [Aerb.gov.in](http://Aerb.gov.in)

### Coordinators:

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<b>2</b>	<b>Basic Physics of Nuclear Reactors</b>	<b>2</b>
	Atomic Structure, isotopes, Radioactivity , half life	
	Basics of fission reaction, Moderation, Criticality, Decay heat, Reactivity and Feedback, Breeding	
<b>3</b>	<b>Nuclear Reactor Types</b>	<b>2</b>
	Components of Nuclear Reactor, Present Reactor Types	
	Generation IV Concepts	
<b>4</b>	<b>Radiation sources and Protection</b>	<b>2</b>
	Radiation and its units, Natural background and man made Radiation	
	Biological Effects, Exposure limits and protection, Sources of radiation, shielding	
<b>5</b>	<b>Safety Principles</b>	<b>2</b>
	Safety objectives, Defence in depth philosophy, Multiple barriers, Rad-waste management	
	Levels of defence, Redundancy, Diversity Principles, Event analysis, core inventory, emergency response	
<b>6</b>	<b>Safety Approach</b>	<b>2</b>
	Deterministic approach- Design Basis Events & Beyond Design Basis Events, Acceptance Criteria	
	Probabilistic approach- Fault tree, event tree, failure rates	

<b>7</b>	<b>History of Events in Nuclear reactors and facilities</b>	<b>2</b>
	INES Scale, TMI, Chernobyl, Fukushima, Windscale, Thorp Reprocessing	
	Kshtym, Vandellos, Tokaimura, NRX, David Besse, Enrico Fermi, Narora Fire, Monju and FBTR Sodium Leak, Radiation over exposures in Industry and Medical applications	
<b>8</b>	<b>Analysis of Some Events in NPP</b>	<b>2</b>
	Heat transfer and Fluid flow prediction, validation, Safety set points, Safety actions for events	
	Spurious opening of Pressuriser valve in a PWR, LOCA analysis Indian PHWR, Station Blackout without Reactor Trip, FBTR	
<b>9</b>	<b>Quality Assurance</b>	<b>1</b>
	Quality Assurance Plan, materials, Design, Fabrication, Maintenance Surveillance, In Service Inspection, Training & Qualification, Quality Audit	
<b>10</b>	<b>Siting of Nuclear plants</b>	<b>2</b>
	Site evaluation Stages, Site Rejection Criteria, Earthquake, Geological criteria, Meteorological considerations	
	Flooding, Tsunami, Shoreline erosion, chemical explosion, Radiological impact study, Radioactivity pathways to humans, environmental Impact study	
<b>11</b>	<b>Engineered Safety Systems</b>	<b>2</b>

	Shutdown systems in PWR,BWR,PHWR, Reactivity Worth of shutdown system, Trip Signals, Safety Logic		
	Operating Environment, Grouping of safety systems, Heat Removal systems, Emergency Core Cooling, Containment and subsystems		
<b>12</b>	<b>Assessment of Radiological Consequences</b>	<b>1</b>	
	Basis of Containment, Quantity of Radioactive materials, Neutron activation of Structures, Transfer and deposition in buildings, Containment leak rate, Environmental Transport and Deposition, source term		
<b>13</b>	<b>Safety Regulation In India</b>	<b>3</b>	
	Atomic Energy Regulatory Board, functions, safety Documents, Safety Review of site, design, regulatory inspections, safety review for PFBR, Koodankulam		
	Regulatory review of operating plants, Licensing stages, licensing of operating personnel, Training simulator, safety up-gradation Review after TMI Chernobyl,		
	Review after Fukushima, safety review for decommissioning, Safety Review of Radiation Facilities, medical X-ray units, Gamma irradiators		
<b>14</b>	<b>Safety Practices in Indian NPP</b>	<b>3</b>	
	Radiological Protection to workers and public, Dose limits, Health physics, AERB Review		
	Environmental radiological surveillance, Radiation around Coal		

	and Nuclear Power plants, Emergency Preparedness and planning, on-site emergency	
	Offsite Emergency Plans, National Disaster Management Authority, Crisis management Group of DAE, State and District level Committees, Emergency Exercises	
<b>15</b>	<b>Passive Safety</b>	<b>2</b>
	Definition, Categorization, Passive Reactor Shutdown systems for PHWR, FBR, Passive Decay Heat Removal Systems for PWR,PHWR,	
	Passive safety for containment cooling, Passive containment spray, hydrogen removal through PAHR, Passive features of AP600 and Advanced Heavy Water Reactor Designs, Issues related to Passive safety	

### References:

1. Vaidyanathan.G., Nuclear Reactor Engineering(Principles and Concepts),S.Chand & Company, New Delhi, 2013.
2. Jacques LIBMANN,Elements Of Nuclear Safety, Les Editions de Physique 1996.
3. Nuclear Power Reactor Safety. By E. E. Lewis. John Wiley and Sons, Inc., New York (1977). 630 pp
4. Gianni Petrangeli, Nuclear Safety, Butterworth Heinemann, 2006,488 pp.
5. NPTEL WEB COURSE on Nuclear Reactor Technology, K.S.Rajan, 2013