

Teaching Notes

Operational Reactor Safety Course

Lecture: 1 – Introduction and Overview

Objective:

To provide a course overview by reviewing the course lectures and course objective which is to develop a fundamental understanding of the technical and operational aspects of reactor safety.

The second part of the lecture is to give students a broad overview of nuclear reactors (PWRs, BWRs and HTGRs) to be followed by a review of basic nuclear reactor physics. The broad overview of reactors is to give students the big picture of what a reactor is and how it works to be followed by more detail in terms of the fundamentals which will follow in subsequent lectures.

Key Points to Bring Out:

<u>Slide number</u>	<u>Points</u>
2-6	To be sure students appreciate what the course is about as well as Expectations and grading of the course
6-9	Explanation of the complete fuel cycle to appreciate the source of Uranium, mining, milling, conversion, enrichment, fabrication and back end. Fuel made in pellets source of fission energy
10-19	Review how electricity is made – need for heat removal – basics of Power conversion, Operating reactor types to show that there are many, the fission process, energy released per fission, creating the core from the uranium – focus on pins, assemblies and configuration in the reactor vessel
20	Take some time on this slide to explain the key elements of core Design and how that affects how much power you can produce, material limitations and how core design in terms of core power distributions is important to allow for maximum power generation. Core heat removal is important to prevent fuel failure as are the safety systems to prevent core damage if key systems are lost.

Lastly discuss the need for the containment or confinement of radioactivity should fuel failures or damage occur. Do not forget the purpose – namely electricity production.

- 21-23 These slides are intended to show the entire plant configuration in Terms of how it is really organized – go over locations of key equipment on slide #21 and then make the point on the schematic that it is a complex system of many support systems which require monitoring and control which leads to slide of the ABWR control room. Summarize by reinforcing notion that the objective is to make electricity safely.
- 26-29 Explanation of boiling water reactors – key points – like a fossil Boiler – boiling in reactor vessel, steam separators, dryers, direct cycle to turbine generator. Point out need for recirculation pumps for core cooling, different type of fuel bundles due to boiling in core – channels needed to assure adequate core cooling, control rods in between fuel elements – run rodded which need to be moved monthly to maintain even burnup – fuel has burnable neutron absorbers, to deal with depletion.
- 30-35 Pressurized water reactors – explain differences in terms of Operating pressures, no boiling – inclusion of steam generator, pressurizer, main coolant pumps, use of boron for depletion, containment structure, core configuration.
- 36-39 Gas cooled reactors – prismatic and pebble, history – Peach Bottom, Ft. St. Vrain, helium coolant, explain power conversion cycle – direct cycle Brayton – single phase helium coolant – NNGP, fuel type difference – ceramic coated particles, prismatic – requires refueling – pebble online refueling.
- 40 Review key features of different reactor types focusing on PWR And BWR features in fuel design, enrichment, number of pins per assembly and number of assemblies.
- 41-44 Reactor Physics Review – Neutron cross sections – emphasize the Possibilities for neutron interaction – each with its own likelihood of occurrence. Discuss energy dependence on cross section using uranium 235 and 238 as examples – explain resonance regions and how important it is for thermal reactors to have enough neutrons to survive the absorption and scattering to end up in the thermal energy range. Here is where the selection of materials matters for the core.
- 45 Fission chain reaction – summarize the possibilities for absorption

And scattering so the enough neutrons survive. – explain criticality and subcriticality.

46-52

Discuss the energy of fissioned neutrons – spectrum and how the 200 Mev per fission is achieved which must be removed from the core. Examine the fission product mass distribution showing how the fission products contribute to neutron absorption affecting the number of neutrons available for fission. Review decay chains using the chart of nuclides that need to be tracked in core physics analysis.

53

Conclude with a brief discussion of reaction rates in terms of what Is the governing equation for power production and key issues in how long a core can operate – fuel depletion, boron or burnable poison loading, reactivity swing, refueling strategies. Engage in discussion of how to design a core to fit the power needs.

MIT OpenCourseWare
<http://ocw.mit.edu>

22.091 / 22.903 Nuclear Reactor Safety
Spring 2008

For information about citing these materials or our Terms of Use, visit: <http://ocw.mit.edu/terms>.