104 Period 17: Nuclear Energy – Consequences of Its Use

1. As you watch the videos in class today, look for a pro-nuclear or anti-nuclear bias on the part of the video producers, narrators, and interviewers. Which ones had a very evident bias?

   While most of the video clips seem to have no blatant bias, a few do. The video clips of the breeder reactor (made in the 60's) seem pro-nuclear, while Donahue seems anti-nuclear as does the clip of the Simpsons. The clip about nuclear waste disposal seems to have a pretty blatant pro-nuclear bias.

2. a) What are the three main types of nuclear reactors? Make sure you understand the components of each type, and the advantages and disadvantages of each from a safety perspective. b) Does the U.S. have the newest, safest nuclear reactors?

   a. (1) Graphite moderated, water cooled reactor (Chernobyl type), (2) Water moderated and cooled reactors, and (3) Graphite moderated, gas-cooled reactors. (Textbook chapter 17 describes each type in detail.)

   b. The reactors in operation in the U.S. are water moderated and cooled reactors, which are much safer than the Chernobyl type reactors, though not as safe as the newer graphite moderated, gas-cooled reactors now used in Europe. The reason that the U.S. does not have the newest, safest reactors is that no new nuclear reactors have been built in the U.S. in over a decade due to strong anti-nuclear sentiment.

3. What type of reactor is a) an "RBMK"? b) a "magnox" reactor? c) a "PWR"?

   a. An RBMK reactor is the Chernobyl type reactor--graphite moderated, water cooled. b. A magnox reactor (named for magnesium oxide cans which hold the uranium oxide fuel) is a graphite moderated, gas cooled reactor (as is an AGR--an Advanced, Gas-cooled Reactor). c. A PWR (Pressurized Water Reactor) is a water moderated and cooled reactor.

4. a) What is the difference between and "meltdown" and an "uncontrolled chain reaction"? b) Which situation is worse? c) What occurred at Chernobyl? b) What occurred at Three Mile Island?

   An uncontrolled chain reaction, which occurred at Chernobyl, is a more dire circumstance than a meltdown, which occurred to a limited extent at Three Mile Island.

Loss of coolant in a Chernobyl-type reactor may result in an uncontrolled chain reaction, in which the fission rate accelerates out of control, and may result in an explosion or meltdown. A meltdown may even occur without an uncontrolled chain reaction due to the remaining heat generated by the decaying fission fragments. Although the use of water as a moderator precludes an uncontrolled chain reaction from happening in reactors operating in the U.S., a partial meltdown could occur if coolant is somehow lost.

5. a) What was the cause of the Chernobyl accident? b) What was the main safety concern immediately after the accident? c) Presently, what is the greatest danger at Chernobyl?

   a. A mishandled safety exercise (exacerbated by a critical design flaw) caused the water coolant to boil to steam, which caused the fission rate to run away generating enough heat to dissociate the steam into hydrogen and oxygen, which then recombined explosively, blowing the lid off the reactor core, at which point the graphite moderator caught fire and burned for days.

   b. Initially, there was concern that there might be enough fuel concentrated below the reactor core to undergo another uncontrolled chain reaction, but it was found to have mixed with sand and glassified and was not concentrated enough to sustain such as reaction.

   c. Presently, the greatest danger is that of the massive reactor lid falling and kicking up a great deal of radioactive dust which could escape through the holes in the sarcophagus and spread into the atmosphere.

6. What is the benefit of using water as both the moderator and the coolant in a nuclear reactor?

   If coolant is lost, then the moderator is also lost. Since a moderator is necessary to sustain a chain reaction, then loss of coolant cannot result in a runaway chain reaction.

7. a) How long will it take for radioactive waste to reach radiation levels on the order of natural background radiation? b) What problems can you foresee in trying to find a place to store it for this length of time?

   a. Keep in mind that there is high level radioactive waste, such as spent fuel rods, and low level radioactive waste coming from many other sources. According to the video clip seen in class, higher level radioactive waste will become less radioactive by a factor of 30,000 in 1000 years and in 10,000 years will be less radioactive than uranium ore (such as that seen in class).

b. 10,000 years is a long time! We may choose a storage facility to be in a relatively uninhabited, geologically stable region, but who is to say what that region will be like 10,000 years from now.

8. When there seem to be all these problems associated with nuclear power, why would anybody be interested in using or developing nuclear power. Compare the advantages and disadvantages of nuclear power with other energy sources.

Nuclear reactions can produce a million times more energy than chemical reactions (such as burning fossil fuels. Also, nuclear power plants do not produce greenhouse gasses. However, there are power plant safety issues and the problem of nuclear waste disposal.

8. a) What is the fuel used in a conventional nuclear reactor? b) What is the fuel used in a breeder reactor? c) Why don't breeder reactors need a moderator? d) What is the main advantage of a breeder reactor over a conventional reactor?

a. The relatively scarce U-235 (Only 0.7% of natural uranium is the U-235 isotope.)
b. 85% Uranium-238 and 15% Plutonium (which is created from U-238)
c. The reaction uses fast neutrons, so no moderator is needed to slow them down.
d. U-238 used by breeder reactors is much more plentiful than U-235 used by conventional reactors. Also breeders produce more plutonium than they use.

10. a) What is the difference between fusion and fission? b) What would be the advantage of a generating electricity using a fusion reactor rather than a fission reactor? c) What is the main difficulty with sustaining a controlled fusion reaction?

Fusion involves the joining of smaller nuclei to make larger nuclei, while fission involves the breaking apart of large nuclei into smaller nuclei. Both can be exothermic.
b. A fusion reaction like that occurring in the sun fuses hydrogen into helium. Hydrogen is plentiful on Earth (from water) and the reaction produces a very high energy yield.
c. Temperatures of nearly a million degrees are required, and that is too hot for any material to hold the reactants. The reactants must be held in place using very strong magnetic forces and this isn't a trivial problem.