Unit 4: Radioactive Waste

Objectives

To make students aware of nuclear waste shipments and the safeguards in place.
To help students become more familiar with the Federal agencies involved in waste transportation.
To fully educate youngsters on nuclear waste transportation as a public policy issue.

At the conclusion of this unit the student should be able to --

Describe the sources, handling, and disposal of radioactive wastes generated by nuclear power plants.
Distinguish between high- and low-level radioactive waste.
Identify the agencies having oversight responsibilities in the designation and storage of radioactive waste.

Investigation and Building Background

1. Introduce term:

Students have little or no accurate knowledge of radioactive waste (i.e., sources, handling, and/or disposal).

2. Resources:

Radioactive Waste "Nuclear Reactor Concepts" Workshop Manual, U.S. NRC.
Department of Energy's Yucca Mountain Web site.
Backgrounder on Dry Cask Storage of Spent Nuclear Fuel.

3. Experiment:

Student assembly of the nuclear waste cube. In the U.S. one person's share of high-level radioactive waste from nuclear power plants for a 20-year period could be placed inside the cube. This is the amount of waste that would be left over after all stable materials had been recycled.

4. Generalizing:

Radioactive waste is material that is radioactive that is no longer needed at the plant and can be disposed of.

Questions
Would a small leak of radioactive waste from a nuclear repository be detected? Why or why not?
How would immediate detection of even a very small leak of radioactive waste differ from leak detection of other types of industrial toxic wastes?
Why are there special sites for disposal of low-level wastes?
Why have some States formed coalitions to support a single nuclear waste site that would serve several States?
Why is there a controversy over the selection of a high-level nuclear waste disposal site?
How would it affect health care in your State (e.g., Maryland) if there were no low-level waste disposal sites available?
Are special packaging containers built to protect the contents or keep the contents from getting in contact with the environment?
How are liquids processed to remove radioactive impurities?

Lesson Plan

Greeting...

Today we're going to look into waste -- generally speaking and specifically -- nuclear. This subject, like everything else in life, generates a lot of questions. I'm sure you have a few about the topic. Hopefully, we'll find answers to most if not all of your questions.

What is waste?

In the process of day-to-day living, people produce garbage and trash. Think of how much garbage and trash your family collects in a day or in a week. Think of how much trash results from just one visit to a fast-food restaurant -- from bags, to straws, to soft drink containers.

Industries also have trash and garbage as a result of doing or making something. The leftovers of an industrial process are called wastes.

Like all industries, nuclear power plants produce waste. One of the main concerns about nuclear power plants is what to do with the waste. This brings us to our second question.

Why is this such a problem?

The problem with nuclear power plants is not the amount of waste they make, which is quite small compared to other industries. The problem is that some nuclear power plants wastes are radioactive. Nuclear power plants are not the only producers of radioactive waste. A large amount of radioactive waste is produced by hospitals and other industrial processes. The central concern is that all producers of radioactive waste must ensure that special care is taken to dispose of these materials and also to protect workers, the public, and the environment.

The way it is disposed of depends on how radioactive the waste is, the half-life of the waste, and the physical and chemical form of the waste. These considerations help identify appropriate ways for disposing of nuclear waste.

Introduce the class activity "nuclear waste cube." [Classroom Activity 6]

Student assembly of the nuclear waste cube. In the U.S. one person's share of high-level radioactive waste from nuclear power plants for a period of 20 years could be placed inside the cube. This is the amount of waste that would be left over after all stable materials had been recycled.

Radioactive waste is material (solid, liquid, and/or gaseous) that is no longer needed at the plant, has no further value, and can be disposed of. Let me give you some examples of radioactive waste:

Radioactive fission products inside the cladding of fuel assemblies
Radioactive activation products that are collected in filters and demineralizers in the reactor cleanup systems
Paper towels or rags used to wipe up radioactive water
Contaminated pieces of equipment
The pressure vessel, plumbing, and containment structures from a closed or decommissioned facility
Radioactive waste from nuclear power plants is classified as being either low- or high-level waste.

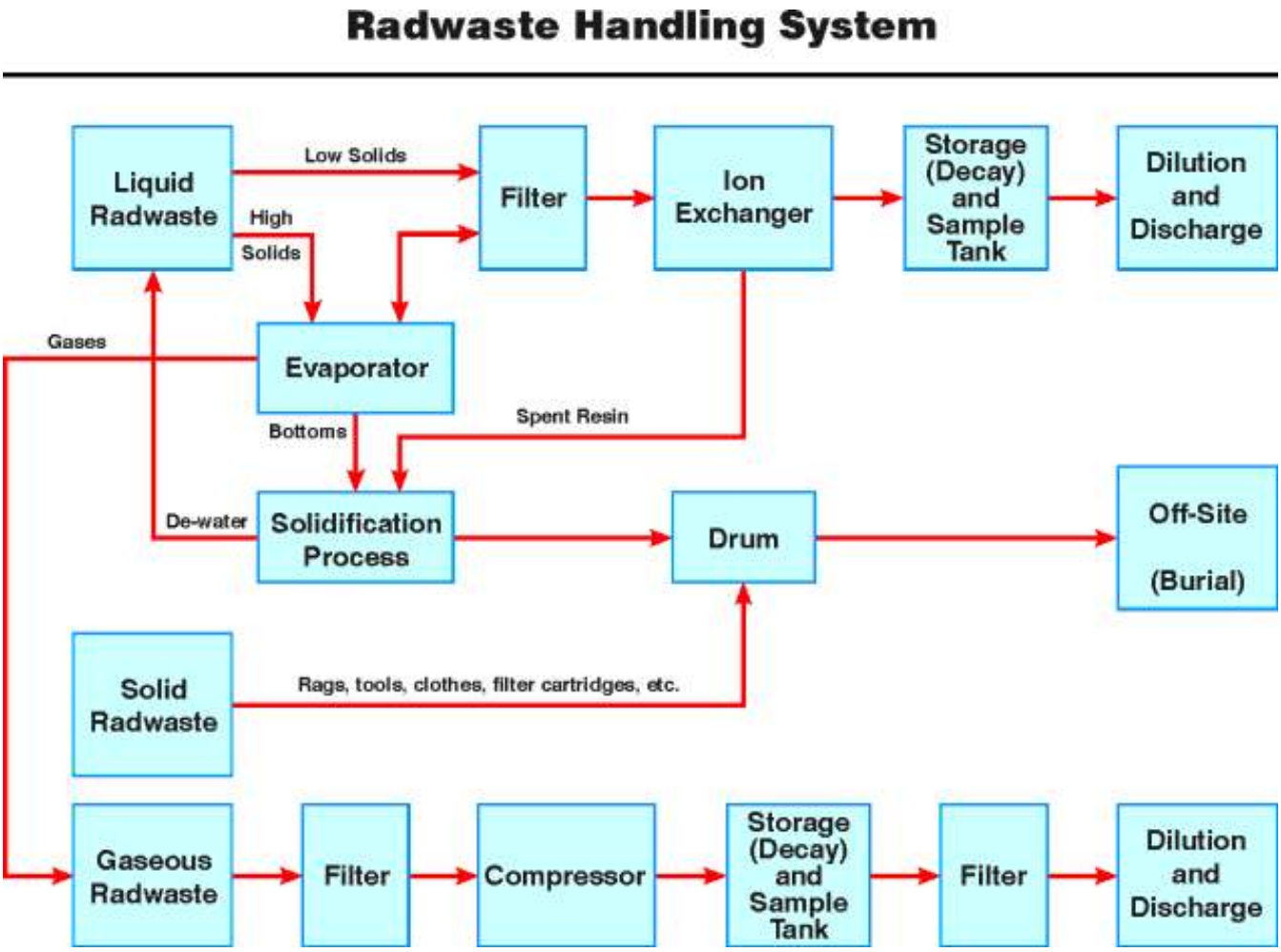
What is low-level waste?

Waste that is only slightly radioactive and gives off small amounts of radiation is called low-level waste. Low-level waste is produced in virtually every state by hospitals, universities, companies, and nuclear energy plants. This waste includes such things as filters, cleanup rags, lab supplies, and discarded protective clothing.

Most radioactive waste from a nuclear power plant is low-level. The principle sources of low-level radioactive waste are the reactor coolant (water) and the components and equipment that come in contact with the coolant. The major constituents of low-level waste from a nuclear power plant are activation products and a very small percentage of fission products (if any leaks out of the fuel rods). It does not include used fuel from the reactor fuel assembly.

Because it emits only small amounts of radiation, low-level waste is usually sealed in steel drums and buried at special sites. Today, most of the low-level waste from nuclear power plants in the U.S. is disposed of at two sites: Barnwell, South Carolina, and Hanford, Washington. Drums containing low-level waste are placed in specially designed trenches and are covered with at least six feet of soil and packed clay. To ensure that the materials remain undisturbed, the trenches are constantly monitored to detect radiation.

In this transparency, we see a typical radioactive waste handling system. (Note: Trace the waste paths.)



The radioactive particles in low-level waste emit the same types of radiation that everyone receives from nature. Most low-level waste fades away to natural levels of radioactivity in months or years. Virtually all of it diminishes to natural levels in less than 300 years. In the U.S. there is strict regulation of low-level waste.

The U.S. Nuclear Regulatory Commission, for example, licenses many of the facilities that produce low-level waste, including nuclear power plants. It also regulates low-level waste disposal. The U.S. Environmental Protection Agency, on the other hand, develops general standards to protect the public from radiation.

The U.S. Department of Energy coordinates national planning with the states for managing low-level waste.The U.S. Geological Survey offers technical assistance with studies of hydrology and geology of proposed sites.

Legislation passed by Congress requires state governments to be responsible for disposing of the low-level waste generated in their states or for joining a regional compact. State governments are also responsible for selecting and licensing a site according to Federal standards and monitoring its operation.

What is high-level waste?

Waste from power plants that is highly radioactive is called high-level waste. For example, about 99 percent of high-level waste from commercial nuclear power plants comes from used or spent nuclear fuel (uranium pellets inside metal fuel rods) that has released much of its energy. Certain changes take place in the fuel during the fission process.

Most of the fragments of fission -- the pieces left over after the atom has split -- are radioactive. Over time, these trapped fission fragments reduce the efficiency of the chain reaction. So, about every 18 months or so, the oldest fuel assemblies, which have already released their energy, are removed and replaced with fresh fuel.

Fuel that has been removed from the reactor is called spent fuel. Spent fuel is highly radioactive, and this radioactivity produces a lot of heat. Spent fuel, after being removed from the reactor, is stored at nuclear plant sites in steel-lined, concrete vaults filled with water (or in dry storage casks that are air cooled). The water cools the used fuel and acts as a shield to protect workers from radiation.

During storage, the spent fuel cools down and also begins to lose most of its radioactivity through radioactive decay, which we've already discussed. In three months, for example, the spent fuel will have lost 50 percent of its radiation; in one year it will have lost about 80 percent; and in 10 years it will have lost 90 percent. Nevertheless, because some radioactivity remains hazardous for thousands of years, the waste must be carefully and permanently isolated from the environment.

While storage on site has been environmentally safe, what is needed today is a permanent disposal site, or repository, for existing and future high-level waste. To date, scientists around the world agree that deep underground disposal is the way to solve the high-level waste storage problem.

In fact, deep underground geologic repositories, have been endorsed by independent scientific organizations such as the National Academy of Sciences. [Instructor might wish to identify these organizations.]

In 1982, the U.S. Congress passed the Nuclear Waste Policy Act. This law set up a schedule for selecting a site, constructing, and operating America's first high-level nuclear waste storage facility. In 1987, Congress directed DOE to explore Yucca Mountain for a repository. In February 2002, DOE recommended that Yucca Mountain be developed as such a use.

However, before the site can be approved, or a repository built and operated, there must be scientific proof that public health and safety will be protected for thousands of years. The facility must meet strict safety requirements of the U.S. Nuclear Regulatory Commission. Additional oversight would be provided by the U.S. Environmental Protection Agency, the State of Nevada, and a Technical Review Board appointed by the President of the United States.

This high-level waste will most likely be converted into a ceramic material that will not rust, melt, or dissolve, even over very long periods. This ceramic waste will then be sealed in heavy metal canisters which will be buried deep underground in solid rock formations. Repositories may be located in stable, dry types of rock formations because it is absolutely necessary that radioactive substances do not leak into underground water.

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Nuclear energy, a powerful force that should never be treated lightly, requires a high degree of professional and technical care. But neither should its risks be exaggerated. The technology exists to isolate high-level waste safely and responsibly, without harm to humans or the environment. Creating a permanent repository will help ensure that. And, with the help of nuclear energy, America will have clean, abundant electricity in the years ahead.

Answers to Questions from Radioactive Waste Unit Outline:

1. Q: Would a small leak of radioactive waste from a nuclear repository be detected? Why or why not?
A: Yes, radiation can be detected with devices similar to and including Geiger counters.
2. Q: How would immediate detection of even a very small leak of radioactive waste differ from leak detection of other types of industrial toxic wastes?
A: Because radioactivity can be easily detected with Geiger counters, it would be easier to detect than most other hazardous or toxic wastes. Leaks of hazardous or toxic wastes other than radioactive wastes are often detected by smell, color, or sensitive chemical analytical methods which take time to perform.
3. Q: Why are there special sites for disposal of low-level waste?
A: Because it must be isolated from the environment.
4. Q: Why have some states formed compacts to support a single nuclear waste disposal site that would serve several states?
A: The Low-Level Radioactive Waste Policy Act passed by the U.S. Congress in 1980 requires

each State to provide for disposal of the low-level waste produced within its borders.
5. Q: Why is there a controversy over the selection of a high-level nuclear waste disposal site?
A: Because the waste that will be stored in these sites is highly radioactive and will remain so for thousands of years, many people don't want it located near them. They are worried that some of the radioactive material may somehow get (leak) into the environment.
6. Q: How would it affect health care in your State (e.g., Maryland) if there were no low-level waste disposal sites available?
A: If no low-level waste site is available, radioactive materials may not be used in the state.
7. Q: Are special packaging containers built to protect the contents or keep the contents from getting in contact with the environment? How are containers or a burial site designed to prevent the contents from entering the environment?
A: They are designed to keep the contents from getting in contact with the environment.
8. Q: How are liquids processed to remove radioactive impurities?
A: a. filtering
b. routing through demineralizers
c. boiling off the water and leaving the solid impurities to be processed as solid waste
d. storing the liquid to allow the radioactive material to decay

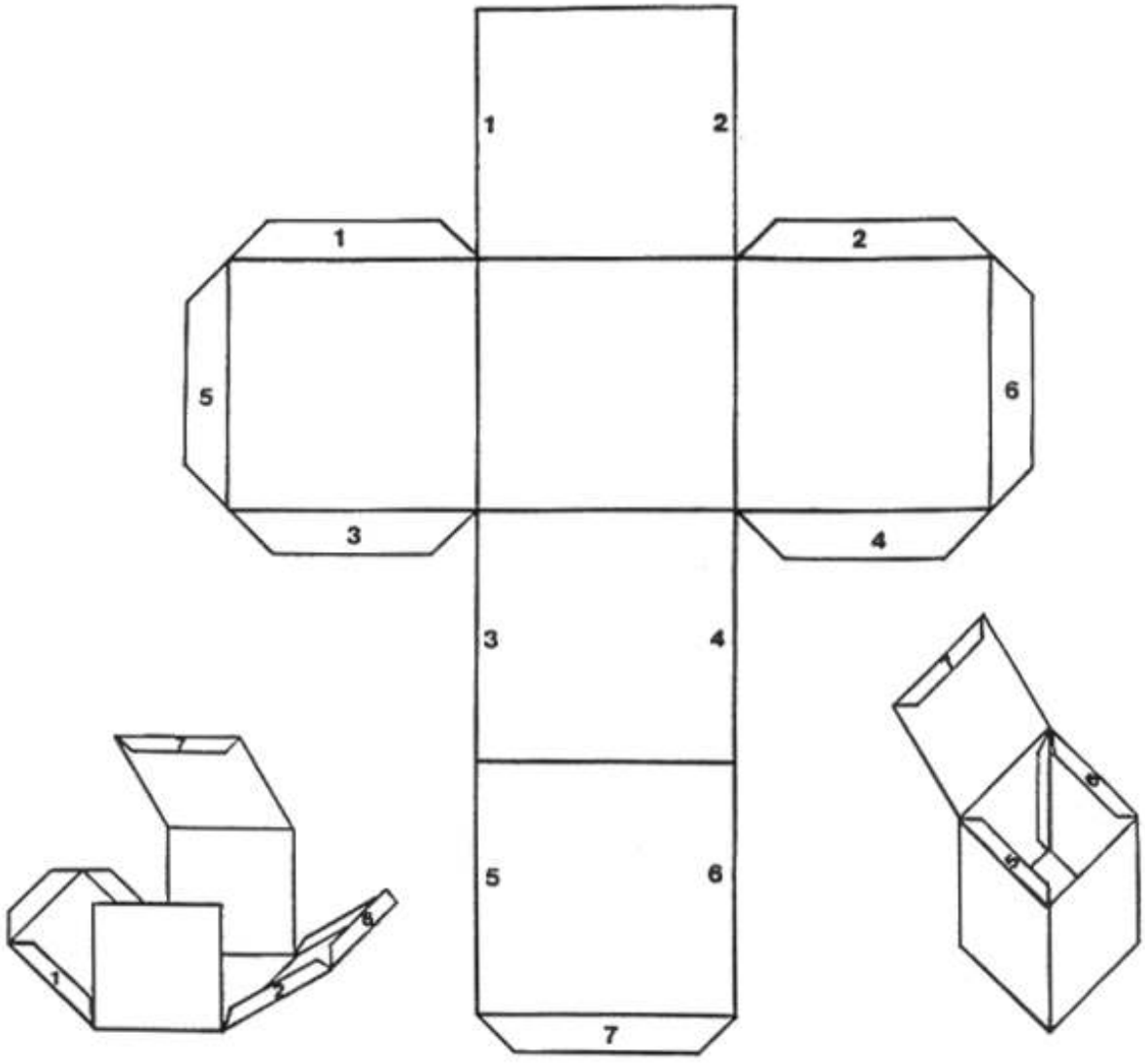
Classroom Activity 6: Nuclear Waste Cube

NUCLEAR WASTE CUBE

Materials	scissors glue or tape

Directions:

Using the diagram as a guide, cut out and fold the pattern to make a cube.



In the United States, one person's share of high-level radioactive waste from nuclear powerplants for a 20-year period could be placed inside the cube. This is the amount of waste that would be left over after all usable materials had been recycled.