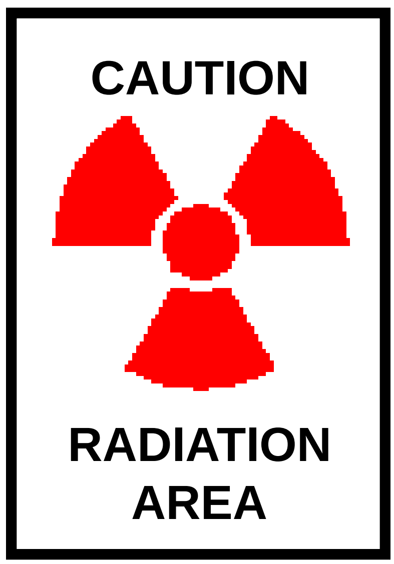
Nuclear Energy - “Will I glow in the dark?”

July 1, 1994



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Community Education Mission Statement

To be a catalyst between the resources of communities, corporations and citizens throughout New Jersey and Pennsylvania that will provide the synergy and commitment of business, industry, educators, parents and children. And to utilize GPU employees, and their families, as a resource to find creative ways to make a real and lasting difference in our communities.

UNIT OBJECTIVES

The student will be able to:

1. define radiation
2. compare the following types of radiation - alpha, beta, gamma, and n-particle
3. discuss the processes of fission and fusion
4. explain how nuclear power is used to generate electricity
5. evaluate the use of nuclear energy as a viable alternative to the burning of fossil fuels for power generation
6. explore career opportunities in nuclear energy related fields
7. discuss nuclear applications in society today

Let us start this unit with a very brief review of some general concepts you have covered in your past work in science. You will recall that all material is made of matter. Matter is defined to be anything which has mass and occupies space. Matter is found in the form of atoms. Everything around you, including your own body is composed of atoms. Each chemical element, such as oxygen, carbon, or iron is composed of a particular type of atom.

Atoms are wonderful units composed of three basic particles; protons, neutrons, and electrons. Each of these particles has a given set of characteristics as described here. Protons are subatomic particles found in the nucleus (center) of the atom. They have a mass of 1 atomic mass unit and a positive charge of 1. Neutrons are also located in the nucleus of the atom. Neutrons also have a mass of 1 atomic mass unit but they have no charge. Electrons are much smaller than protons and neutrons. They are found in the area outside the nucleus known as the electron shell or orbitals. Electrons have a negative charge of 1 and are much smaller than protons and neutrons. If you wanted to use their actual mass it has been stated as 9.11x10-28 grams. The actual mass of a hydrogen atom, one proton is 1.66x10-24 grams.1 The ratio between the mass of a proton and an electron is about the same as the ratio between your weight and a candy bar. Usually the mass of electrons are not included in the mass of an atom.

If you recall, one of the basic principles of charged particles, is that opposites attract. This force is what keeps the electrons flying around the atom’s nucleus. Remember, electrons do not move in given tracks. They may be anywhere within their energy level, known as quantum states. (The quantum state prohibits them from going into the nucleus.)

In an atom, there are always an equal number of protons and electrons to maintain a neutral charge. The number of electrons associated with a particular atom may change if the atom combines with another atom. For example, one atom of sodium (Na) has 11 electrons and 11 protons. One atom of chlorine (Cl) has 17 electrons and 17 protons. If the two atoms combine to form NaCl (common table salt) the sodium atom loses 1 electron, resulting in a positive ion (cation), and the chlorine atom gains 1 electron, resulting in a negative ion (anion). However, the number of protons will always remain the same.

It is the number of protons in the atom's nucleus which determines what element you have. You may find that there are a variety of different forms of atoms for the same element. These are called isotopes. Every isotope of a given element will have the same number of protons and electrons, but different numbers of neutrons. Adding and removing neutrons will change the mass of the atom and affect the stability of the nucleus. These nuclear particles are the key to the production of atomic energy through the fission process. Let's look now at what fission is.

What is fission?

In its simplest form, fission is the splitting of the nucleus of an atom. This process could be compared to breaking a rack of pool balls. The nucleus is tightly packed with protons and neutrons. A particle, in this case a free neutron, will be shot into the mass causing it to become unstable. The instability will cause the nucleus to split into two smaller more stable masses. When the split takes place, energy, in the form of heat, and more free neutrons will be produced. This energy is the start of our power generation process in a nuclear power plant.

What is fusion?

Fusion is defined as a nuclear reaction in which nuclei combine to form more massive nuclei with the simultaneous release of energy.
Example

The fusion of the hydrogen isotopes deuterium and tritium yields helium and a neutron and energy. Written different ways:

deuterium	+ tritium	= helium	+ neutron	+ 14 MeV
^{2}H	+ ^{3}H	= ^{4}He	+ n	+ 14 Mev
lp+ln	+ lp+2n	= 2p + 2n	+ n	+ 14 Mev

More research and engineering is necessary before controlled fusion will be a practical source of energy for generating electricity. Some of this research is being done at the TFTR at Princeton, NJ.

Fusion based power plant will probably not be built until the middle of the next century. Fusion has several distinct advantages. The reaction produces less radioactive waste than the fission process. Also there is a virtually unlimited source of fuel which is available anywhere in the world. Deuterium can be found in small qualities in water and the neutrons produced in fission or fusion reactions can be used to produce tritium from deuterium.

OPTIONAL DEMONSTRATION ACTIVITY for FISSION

Materials: glass marbles and magnetic marbles

Procedure: Explain to your students that one particle type in the nucleus is neutral and one of the types of marbles has a "charge," these will be the protons. The glass marbles will represent the neutrons. Place 12 magnetic marbles and 18 glass marbles together in a mixed pile to represent the nucleus. Take one of the extra glass marbles and shoot it into the mass. It is a good ides to have students stationed all around the mass in a circle to catch the results. If the target nucleus is fissile, capable of fission, it will break apart and some of the glass marbles will escape, while the protons will remain in large clusters. The free "neutrons" will in turn start other fission reactions. If the mass is not fissile it will absorb the glass marble and no free marbles will be produced.

An alternate plan for this demonstration is to start with a mass of 12 protons and 12 neutrons. Add glass marbles a few at a time and then shoot a glass marble into the mass. Record the results. When does the mass break apart? What effect does the size and speed of the projectile have on the result? What proportion of the target nucleus becomes "free" particles during the fusion reaction?

OPTIONAL DEMONSTRATION ACTIVITY for CHAIN REACTION

Materials: Dominoes, meter sticks, Domino Rally set-up is optional

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Procedure: Distribute dominoes to student and instruct them to set them up in such a manner that one domino triggers two or more rows of dominoes. Give one student the trigger and another student the meter stick. Start the reaction and have the students see if they can stop the reaction before it sets of another layer. If they set up several sets of interlocking triggers, they will approximate a large scale reaction. They should see that the meters sticks blocking the reaction are similar to the control rods of a reactor absorbing the free neutrons to slow down or stop a fission reaction.

Diagram 1

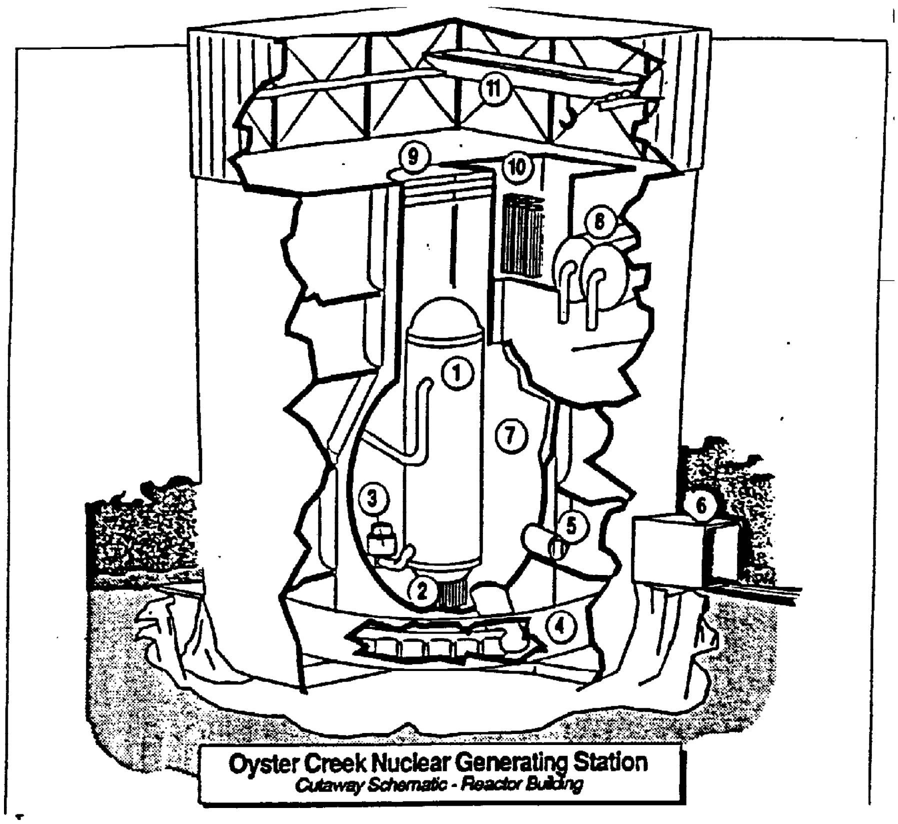
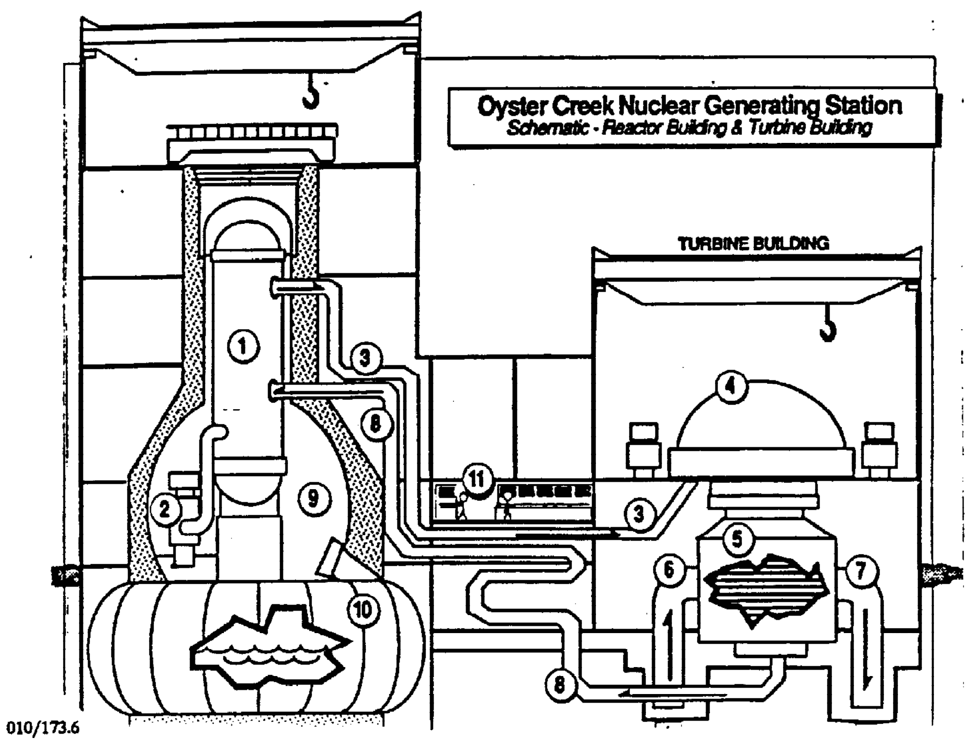


Diagram 2



Answer key to Diagram 1:

Oyster Creek Nuclear Generating Station

Cutaway Schematic - Reactor Building

1 - **REACTOR VESSEL:** Contains the nuclear fuel, steam separators and dryers as well as associated safety related and core support equipment. Inside the vessel is where water is converted to steam.

2 - **CONTROL BLADE HOUSING AREA:** This area allows space for the removal of the control blades from the core, initiating the nuclear chain reaction.

3 - **RECIRCULATION PUMPS (5):** These five pumps circulate water through the bottom of the vessel and up over the core to initiate the water to steam conversion.

4 - **TORUS:** This safety related system acts to suppress any excess pressure that builds up inside the drywell.

5 - **DRYWELL MISSILE SHIELD**: Acts as the primary shield for the personnel/equipment hatch that penetrates the drywell.

6 - **AIRLOCK CHAMBER:** An opening through which vehicles and equipment may enter the Reactor Building.

7 - **DRYWELL:** The primary containment surrounding the major nuclear steam supply components.

8 - **ISOLATION CONDENSERS (2):** Provides an efficient heat removal system when the main steam is unable to maintain its normal flow path through the turbine and condenser.

9 - **REMOVABLE REFUELING PLATFORM:** The primary containment shield over the Reactor Vessel during normal operations.

10 - **SPENT FUEL POOL:** Provides a safe and stable area in which to store used nuclear fuel.

11- **OVERHEAD CRANE:** Used to safely move large objects on and around the refueling floor

Answer key to Diagram 2:

1 -	REACTOR VESSEL
2 -	RECIRCULATION PUMPS (5)
3 -	MAIN STEAM LINE
4 -	TURBINE/GENERATOR
5 -	CONDENSER
6 -	INTAKE - COOLANT WATER
7 -	DISCHARGE - COOLANT WATER
8 -	FEEDWATER LINE
9 -	DRYWELL (CONTAINMENT)
10 -	TORUS
11 -	CONTROL ROOM

The steam cycle begins in the **Reactor Vessel (1)**, where water is kept under great pressure, is heated by the nuclear fuel, and boils. Water is kept circulating through the reactor core by five **Recirculation Pumps (2)**.

Steam moves through the **Main Steam Lines (3)** from the Reactor Vessel to spin the **Turbine Generator (4)**.

Spent steam from the Turbine flows down to the **Condenser (5)**. In the Condenser, Coolant Water from the **Intake Canal (6)** passes through the inside of condenser tubes, while hot spent steam from the Turbine flows outside the tubes. Coolant Water, now slightly warmer from the heat exchange process, leaves the Condenser and is emptied into the **Discharge Canal (7)**. Meanwhile, the steam that has transformed again into water leaves the Condenser and returns to the Reactor Vessel through **Feedwater Lines (8)**, where the same water begins the process again.

The **Drywell (9)** is the containment source for the nuclear reactor, and is built to withstand a large amount of pressure. The **Torus (10)** is a very large pressure suppression pool connected directly to the Drywell.

Safe and efficient operation of the entire plant is directed by operators from the **Control Room (11)**.

ACTIVITY

Use the included schematic of a boiling water reactor provided in this packet (titled: Oyster Creek Nuclear Generating Station) to follow the described process of energy generation. Have the students write a brief explanation of the process.

Assign research project comparing fossil fuel vs nuclear plant pros and cons. Have students research pros and cons in preparation for debate on the topic: Which power generating system can you live with into the 21st century? Be sure the long range as well as short range impacts to the environment and public health are covered. We have included a poster which covers the generation of electricity using four different processes as an aid for this project.

How is the heat produced in the reactor?

Going back to our explanation of fission, a radioactive isotope, uranium-235 is used as our fuel. Naturally occurring uranium has two principle isotopes, U-238 makes up approximately 99.3% with U-235 comprising the remaining 0.7%. Uranium-238 is not a fissionable substance, or fissile as it is commonly termed. This means that if we shoot the nucleus with a free neutron, the atom will absorb the neutron without splitting. We must use the U-235 isotope for the fission process. In order to sustain a reaction we must enrich or increase the proportion of U-235 to about 3.0%. Note: To make a nuclear weapon device the ore enrichment must be 97% instead of the 3% used in a power plant. This enrichment process currently takes place in a gaseous diffusion plant. The depleted uranium from this process, called “tailings,” is predominantly U-238. This is currently stockpiled and could be used in the future for fuel in a different type of reactor, a breeder reactor.[2]

The U-235 enriched fuel used in the reactor is in the form of small pellets of Uranium Dioxide These pellets are put together into fuel rods, 14 feet long with a diameter of 0.5 inch. The rods are grouped in bundles of 64 to make a fuel assembly. There are 560 such fuel assemblies in the reactor at Oyster Creek. These assemblies are undergoing a controlled fission reaction to produce the heat necessary for steam production. In this reaction, loss of mass is being converted into energy, $E = mc^2$. A sample of the type of reaction which can and does take place is given below.

1 atom of U_{235} + 1 Neutron = 92 Protons and 144 Neutrons (143N + 1N)
(Trigger)

Fission products:				Mass:	
Xe_{139}	=	54 Protons	and	85 Neutrons	138.917840 amu
Sr_{94}	=	38 Protons	and	56 Neutrons	93.915380
3N	=			3 Neutrons (free)	3x(1.00866520)
Total		**92 Protons**		**144 Neutrons**	**235.8592156 amu**

Fission Power:

U_{235}	= 235.043915 amu
N	= + 1.00866520
Total	= 236.0525802 amu

Mass Loss

U_{235} + N	= 236.0525802 amu
Products	= -235.8592156 amu
	0.1933646 amu loss

Using 931.481711 MeV per amu this creates an energy release of 180.1155MeV plus beta and gamma radiation energy.[3]

Now we have generated heat. This heat is used to produce steam. In a boiling water reactor such as Oyster Creek (designed by General Electric), steam is produced in the nuclear reactor. To accomplish this water is used both as the coolant and moderator for the reactor. The steam bubbles generated carry away heat and short life radioactive isotopes that give off gamma radiation. As a result, the entire steam cycle is shielded and is a prohibited (no man's land) area during power operation. The steam produced at the plant drives turbines to which an electric generator is connected. The used steam from the turbines is vented into a condenser which is a giant size vacuum box where the steam condenses. The condensate is again returned to the reactor as feedwater.

The entire condenser is kept under negative pressure. It is almost a perfect vacuum. This also helps prevent contaminated material from escaping directly into the atmosphere. The radioactive products such as Nitrogen 16, Xenon, and Krypton along with traces of particulates are vacuum pumped off to delay lines and tanks to allow them to decay. It is then sent to an off-gas building. With exception to the radioactive bi-products, once the steam is produced, from this point on the plant operates on exactly the same principle as a fossil plant using turbines to generate electricity.

What types of radiation are produced at the plant?

Thus far we have spoken a great deal about nuclear energy, but have not actually defined radioactivity. We know that radiation is energy in the form of moving waves or particles. In essence radioactivity is the phenomenon associated with the spontaneous disintegration of heavy unstable atoms.[4] In order to become more stable, an atom must get rid of excess energy within its nucleus. To do this, atoms **decay**; that is they give off radiation.

Fission products, the smaller atoms left after an atom undergoes fission, are radioactive. Many of these will continue to give off heat and radiation because they continue to decay.

There are four basic forms of energy commonly associated with radioactive decay:

1. **alpha** particles - (may also be called a He4 nucleus) consist of 2 protons + 2 neutrons, carry positive charge. This type of radiation can be shielded with paper. Uncontrolled exposure to alpha radiation is a concern to internal body organs if ingested.

2. **beta** particles - A neutron could be considered to be a combination of a proton and an electron. When it splits, the electron is given off as a beta particle. Thus they are fast moving electrons, carry a negative charge. They may be shielded by a thin sheet of aluminum, wood, or plastic. This type of radiation is a concern for your eyes and skin. It is also a problem to internal organs.

3. **gamma-rays** - are waves of energy similar to x-rays. It is a concern to whole body.

4. **n-particle** - has no charge, is found near an operating reactor. This form of radiation has a short half-life, about 125 minutes and can be shielded with hydrogenated materials such as water or polycarbons.[5]

Viewing Activity: Please use the *Radiation and You* tape available through GPU to illustrate more information about specific types of radiation. A round table discussion of radiation types, uses, and dangers is suggested as a follow-up activity. The following is a short handout you might wish to use with the tape. The teacher copy follows.

Name___________________________________

RADIATION and YOU

1. When was radiation discovered?

2. What is radiation?

3. What are the two basic types of radiation?

4. What is the difference in the amount of protection you would need for these types of radiation?

5. What is the principal cause of an unstable atom?

6. What are some uses of radiation in society today?

7. What is a radiation Dose? What is it measured in?

8. What factors control the biological effect of a radiation exposure?

9. What are some examples of radiation exposures?

RADIATION and YOU, TEACHER ANSWER GUIDE

1. **When was radiation discovered?**
   It was discovered in 1890.

2. **What is radiation?**
   Radiation is a naturally occurring energy form. It appears as cosmic rays from the sun. Even your body is mildly radioactive. {Potassium-40 is a naturally occurring radioactive element in all of us.)[6]

3. **What are the two basic types of radiation?**
   Ionizing and non-ionizing. Ionizing radiation produces charged particles {alpha, beta} and energy in the form of x-rays, and gamma rays. Non-ionizing radiation is energy such as light, microwaves, and UV energy.

4. **What is the difference in the amount of protection you would need for these types of radiation?**
   Alpha particles can be shielded by paper. Beta particles are more penetrating. They require a thin sheet of metal to shield from them. Gamma rays take a shield of lead or concrete. Microwaves can be shielded by distance or thin metal. UV radiation can be blocked by a thin layer of a substance such as zinc oxide, the white creme lifeguards use on their nose to prevent sunburn.

5. **What is the principal cause of an unstable atom?**
   An imbalance of the number of protons and neutrons.

6. **What are some uses of radiation in society today?**
   We use radiation to sterilize things. The cabinet your lab goggles are sterilized in operates in this manner. We now see irradiated food on the grocery shelves. The milk boxes which do not require refrigeration are examples of this process. We use it to illuminate objects, such as watch dials. We use radiation for medical purposes, in diagnosis and treatment.

7. **What is a radiation Dose? What is it measured in?**
   A radiation dose is an exposure to radiation. The unit of radiation exposure is a REM. This measures the potential biological effect.

8. What factors control the biological effect of a radiation exposure?

Biological effects depend on: 1) magnitude of exposure, 2) length of time of exposure and distance from the source, 3) what part of the body is exposed. The higher the dose the greater the effects. Less than 1000 milligrams per year has no significant biological effects. The limits at a power plant are based on a 5rem per year rate which is the federal limit. The Oyster Creek exposure limit is 80% of the federal limit.

9. What are some examples of radiation exposures?

(Please refer to "A Basic guide to Nuclear Power," page 13, figure 33 for a table of annual radiation exposures.)

100	mrem from natural sources*
200	mrem from radon (Ref. later)
90	mrem from medical sources*
0.5	mrem from nuclear power plants if you live one mile away
1	mrem from an airplane trip, from LA to Boston

average 390 mrem per year

(* *From the USNRC Regulatory Guide 8.29 July 81, page 12.)*

There are three basic principles to be aware of in reducing radiation exposure:

1) **shielding** - protecting you from direct exposure to the source.
2) **distance** - a general rule of thumb is "double the distance, quarter the dose." This works on an inverse square proportion.
3) **time** - the less time exposed, the lower the dose. For example, a radiation rate of 50 mrem per hour will give a 50 mrem dose over 1 hour, 25 mrem in 30 minutes . . . etc.

Note: There is also a MS-Dos computer program, "MicroShield" available for use with students. In this program, the student works with real time shielding problems calculating the distance, thickness, and type of shielding material necessary for a variety of radiation sources. There are sample problems you may work from or you may wish to tailor the program parameters to suit your individual needs and applications.

Grove Engineering will send a free copy of MicroShield 3.0 to teachers for educational use. You will have to write to them for this. Be sure to request a manual with the program. The letter should be on school letterhead addressed to:

Jo Sackville
Grove Engineering Inc.
15215 Shady Grove Road, Suite 200
Rockville, MD 20850
301-258-2727

What are the safeguards at nuclear power plants?

To protect public health and mitigate the consequences of a design-basis accident, the safety systems are designed to a single failure criterion. This means that any single failure will not prevent the safeguard system from performing its intended safety function. The safeguard systems are 100% redundant. (They are duplicated and physically separated from one another.) They also have separated emergency power source for each redundant system.

There is always some risk in any kind of life. Starting with the cave man to technologically advanced societies. In our society there exists a finite risk while driving a motor vehicle, taking an airplane ride or even walking in the streets. Any industrial unit including nuclear power plant is not free from potential risk to the well being of the workers and general public. But attempts are made through design features to minimize such risks.

Name ________________________________

REALITIES of RADIATION

1. **How are radiation workers protected from radiation exposure and contamination?**

2. **What is the difference between radiation exposure and radioactive contamination?**

3. **How are radiation workers and their families protected from bringing contamination home?**

4. **In what ways are particles of contamination removed?**

5. **How do the health risks from radiation at a plant compare to health risks associated with the general public?**

6. **How are workers protected by the standards established by government?**

7. **What factors must be accounted for in calculating the best choice for methods and protection in working with radiation?**

REALITIES of RADIATION, Teacher Answer Guide

1. **How are radiation workers protected from radiation exposure and contamination?**
   The first line of defense against radiation exposure and contamination is training. Only specially trained people can work in radiation areas. Protective clothing, equipment and dosimetry also are used to protect the worker.

2. **What is the difference between radiation exposure and radioactive contamination?**
   Radiation exposure is energy the individual absorbs. This occurs everyday within the general public as they walk in the sun, have medical or dental x rays, or just watch television. Radioactive contamination is any loose radioactive material in locations other than planned. It can be on the clothing or body of a person. When contamination is re moved the exposure stops.

3. **How are radiation workers and their families protected from bringing contamination home?**
   Workers and their families are safeguarded through a series of safety precautions at the nuclear facility. There are series of monitors workers must pass through to leave radiologically controlled areas at work. Exposure from a dosimeter is logged and the scan for contamination takes place. Contamination is then removed. Dosimeters are provided to each person working in radioactive or contaminated area. Radiation dose received by a worker is logged upon completion of work. Computer keeps a cumulative log. This is to ensure that the workers have not received radiation dose above Federal limits.

4. **In what ways are particles of contamination removed?**
   If the contamination is on the clothing and cannot be easily removed by vacuuming, the worker is given garments to wear home and the clothing is either decontaminated or dis posed of. If the skin is contaminated, it is washed or tape may be used to remove particles. If the radioactive material has been ingested or inhaled, the worker will eliminate it through natural bodily functions and it will not transfer to others.

5. **How do the health risks from radiation at a plant compare to health risks associated with the general public?**
   The health-related risks of working with radiation are far less than the risks many people take in their everyday life. Scientific studies have shown that the health risks are negligible for this occupation. The incidence of risk is higher for such occupations as mining and quarrying, construction, agriculture, transportation and utilities.

6. **How are workers protected by the standards established by government?**
   Very stringent regulation by the U.S. government protects the worker and the public.

7. **What factors must be accounted for in calculating the best choice for methods and protection in working with radiation?**
   Factors to consider are time of exposure and strength of exposure. Decreasing the strength of exposure at the expense of greatly increased time of exposure may result in a larger overall dose.

What about the waste from the system?

The fuel assemblies in our nuclear plant are put in place and can run continuously for about 2 years. About every two years the plant is shut down for refueling. At this time, about one third of the fuel assemblies are replaced. The remaining two thirds have their positions rotated to optimize fuel use. The one-third that is removed is stored in spent fuel pools located within the reactor building. After the assemblies have cooled sufficiently they are moved into 100 ton casks and stored in specially designed storage facilities on site. These facilities are shielded and both earthquake and bomb proof.

Eventually there will be a national deep depository for storage of this material. It will be designed to allow for a 100 year retrieval window. After the century of access has expired the system is self-sealing to return the radioactive materials to nature safely and protect the general public.

There is also low-level red waste generated by the plant in solid, liquid, and gaseous forms. The primary source of this material is reactor water clean-up, minor spills, and maintenance work (anti-contamination clothing). This low-level waste is taken to a federal repository for shallow burial, as opposed to deep burial of a mile underground. Everything to be buried is sealed, and the site itself is sealed from groundwater. The kind of isotopes are limited to things which will decay over centuries as opposed to millennia.

What are allowable doses?

Oyster Creek follows the ARARA (as low as reasonably achievable) policy. The whole body federal limits for annual occupational exposure is 5 rem and that for the general public is 0.1 rem. At Oyster Creek the annual exposure limit to radiation workers is limited to 80% of the federal limit. The occupational radiation exposure allowed for whole term pregnancy is 0.5 rem. Sources of radiation dose to general public (Ref.: “Basic Guide to Radiation” page 13)

Annual Dose	Source
26 mrem	Natural background/cosmic rays at sea level
5 mrem	Air/charged clouds
7 mrem	Building materials - bricks, granite stone, etc.
25 mrem	Foods
2 mrem	A single airplane round trip between Boston to LA
26 mrem	Ground
.6 mrem	Color Television (4 hours of viewing/day/year)
10 rem	A single chest X-ray
	Nuclear Power Plant:
1.8 mrem	° At site boundary (9 hours/day/year)
0.5	° One mile away (24 hours/day/year)

What are some of the uses and occupations associated with nuclear energy today?

There are a wide variety of uses and occupational fields related to nuclear energy today. We have listed a few of these here for you to consider.

In the area of tasting, nuclear energy is used for non-destructive examination of people and objects. Industrial radiography, similar to an x-ray but using a gamma ray source, is often used to examine items such as thick walled pipes and valves for flaws such as cracking or voids or the effects of erosion. Occupations involved with this aspect of nuclear energy use perform quality assurance or inservice inspections.

Radiography and ultrasound are common diagnostic and therapeutic methods in medicine today. In the area of medicine, nuclear energy is used as a source of radiation for cancer treatment. In addition, radioactive isotopes are injected into patients in order to treat certain organs, such as the thyroid, or to locate tumors, or to test the function of certain organs.

Nuclear Energy is used for protection. In smoke alarms the element Americium is used as the ionization source. Weapons and explosives may also employ radioactive substances.

Nuclear energy is used in industry for such processes as fluorescence analysis which looks for characteristic x-rays to determine the content of ores for separation. It is also used to measure the karats of gold if it is present in a dual alloy. In jewelry, radiation is employed to fix the color centers of some gem stones. Radioactive tracers are used on test products. For example, radioactive sulfur could be added to piston rings and then the amount of sulfur in the oil measured to show wear. It is also used for such nondestructive processes as x-raying spot welds and castings for flaws. Radioactive tracers are often used in chemical and biological research to relate source and destination within an organism.

Nuclear energy is used for commercial sterilization. Gamma rays produce milk which can be kept on the shelf instead of in the refrigerator. It is also used for biological sterilization in pest control. Insects are sterilized and then released to block the mating of fertile pairs and eliminate a new generation of pest.

What types of jobs are there at a nuclear power plant?

The Oyster Creek Plant employs approximately 900 people. The following fields are included in the list of occupations:

Administrative - to run the site operations
Electrician
Engineering - chemical, electrical, civil, nuclear, structural, systems analysts
Food service workers
Health professions - doctors, nurses, and health physics personnel
Human Resources
Information services
Licensing professional - environmental and nuclear
Maintenance (custodial)
Mechanic
Metallurgy specialists
Secretarial/clerical staff
Testing professional - do quality assurance in-service inspections
Training positions - involving working with simulators

Culminating Activity: We would like to suggest a student debate on the relative benefits of nuclear power as compared to fossil fuel, hydro-electric, or other alternative power sources.

ENDNOTES

[1]George Gamow, The Atom And Its Nucleus, New Jersey, Prentice Hall Inc. (January 1965), p. 101.

[2]Energy Research and Development Administration, Advanced Nuclear Reactors: An Introduction , Washington D.C., U.S. Government Printing Office (September 1975), p. 3.

[3]John Stevens, technical advisor from GPU Nuclear facility, Parsippany, New Jersey.

[4]Herman Cember, Introduction to Health Physics. second edition, Great Britain, Pergamon Press (1988), pp. 57-60.

[5]Barbara Martocci and Greg Wilson, A Basic Guide to Nuclear Power, Washington D.C., Edison Electric Institute (1987), p. 10.

[6]Realities of Radiation, pamphlet with video tape of same title produced for GPU Nuclear, p. 3.

[7]Radiation Working Training, General Employment Training material from GPU Nuclear, p. 14.

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