FREQUENTLY ASKED QUESTIONS
RADIATION AND NUCLEAR TOPICS

S.C. Radiation History/Overview

Background

South Carolina is a radiological state. From the development of the Savannah River Site near Aiken – in the early 1950s – to the opening of the state's first nuclear power generating facility in 1971 near Darlington, South Carolina has been a forerunner in the use of radiological technology.

South Carolina's role in the history of radiation began in 1950 when the Atomic Energy Commission (predecessor of the U.S. Department of Energy – The USDOE or DOE and the U.S. Nuclear Regulatory Commission – the USNRC or NRC) authorized the design and construction of the Savannah River Site near Aiken, South Carolina. The facility's main role, in the 1950s, involved producing materials used in the fabrication of nuclear weapons.

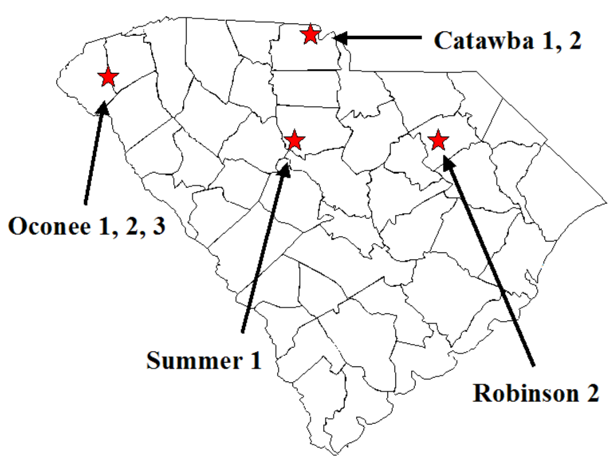
With the end of the Cold War, the Savannah River Site's role changed significantly in its support of the National Nuclear Security Administration (NNSA) of the U.S. Department of Energy (USDOE). The NNSA's Savannah River Site Office (SRSO) is responsible for the Defense Program missions at this site. A new Tritium Extraction Facility has been operational since 2007 at the Savannah River. The NNSA also manages the project that, once construction is completed, will convert approximately 34 metric tons of surplus weapons-grade plutonium to mixed oxide fuel (MOX). The MOX fuel can be safely used in commercial nuclear power plants for the production of electricity.

Currently, four nuclear power generating facilities provide more than 50% of South Carolina's electricity. One additional nuclear power generating facility in the state of Georgia (Vogtle Electric Generating Plant), just beyond the Palmetto State's borders, must also be taken into emergency planning consideration. In total, the state of South Carolina is home to seven reactors; two are located at the Catawba Nuclear Station, one is located at the H.B. Robinson Nuclear Plant, three are located at the Oconee Nuclear Station and one is located at the V.C. Summer Nuclear Station. All seven reactors are Pressurized Water Reactors (PWRs). The Vogtle Electric Generating Plant is home to two additional pressurized water.

Sources of Electricity in South Carolina

Coal	40%
Hydroelectric	2%
Natural Gas	6%
Nuclear	51%
Other	1%

<u>Source</u>: ***Energy Information Administration, 2007***
http://www.eia.doe.gov/



The Oconee plant has the most nuclear capacity of any of the State's plants, with three light water reactors rated at 846 Megawatts (electric) each. The largest reactors, however, are the pair of PWRs at the Catawba plant, rated at 1,129 MW (e) each. The other two nuclear plants are single-unit operations.

Power Generation capacity Per Reactor

Reactor	City	Capacity (MW)	2008 Generation (Million Kilowatt Hours)
Catawba 1	York	1,129	8,773
Catawba 2	York	1,129	10,203
H.B. Robinson 2	Hartsville	710	5,427
Oconee 1	Seneca	846	6,215
Oconee 2	Seneca	846	6,391
Oconee 3	Seneca	846	7,515
V.C. Summer 1	Jenkinsville	996	7,178
Total		**6,472**	**51,702**

Source: **Energy Information Administration**
http://www.eia.doe.gov/

Permanently Shutdown Commercial Reactors

According to the Nuclear Regulatory Commission, the Carolinas-Virginia Tube Reactor (CVTR) in Parr, South Carolina, was shut down on January 1, 1967.

South Carolina Nuclear Notes

In 2008, South Carolina ranked 3rd among the 31 States with nuclear capacity and 3rd in nuclear generation. It has the most nuclear capacity in the southeastern United States.

South Carolina's nuclear industry opened the new century with a new State record for nuclear output: more than 53 billion kilowatt hours. It is the current record.

Santee Cooper Corporation and South Carolina Electric and Gas have applied for a combined license for two (2) AP1000 reactors at the V.C. Summer plant. The targeted completion date for construction will be in 2016 and 2019.

Duke Energy has submitted a combined construction and operating license application for two AP1000 reactors to be built in Cherokee County. The targeted completion date may be as early as 2018.

NUCLEAR POWER PLANT SITE-SPECIFIC INFORMATION

Catawba Nuclear Station

The Catawba Nuclear Station is located six miles north of Rock Hill, on the western shore of Lake Wylie. Unlike sister stations McGuire Nuclear Station in Mecklenburg County, N.C. and Oconee Nuclear Station in Oconee County, S.C., Catawba is jointly owned by North Carolina Municipal Power Agency Number One, North Carolina Electric Membership Corporation, Piedmont Municipal Power Agency and Duke Energy.

In operation since 1985, the site has two nuclear reactors with a power production capability of 2,258 megawatts. The license for Reactor #1 was issued Jan. 17, 1985 and expires Dec. 6, 2024. The license for Reactor #2 was issued May 15, 1986 and expires Feb. 24, 2026. Both reactors are pressurized water reactors.

For emergency planning and response purposes, the 10-mile Emergency Planning Zone is located within York County.

H. B. Robinson Nuclear Plant

The H. B. Robinson Nuclear Plant is located 26 miles east of Florence and west of the Lake Robinson Dam in western Darlington County. The facility is owned and operated by Progress Energy, whose corporate headquarters are located in Raleigh, N.C.

In operation since March 1971, the site has one nuclear reactor with an electric power generating capacity of 710 megawatts. The H. B. Robinson Plant is one of the country's few electrical generating stations with side-by-side coal and nuclear plants. Robinson coal-fired plant, also referred to as Reactor #1, generates 174 megawatts of electricity. It began operation in May 1960. Robinson's nuclear reactor, also referred to as Reactor # 2, generates 710 megawatts of electricity. The license for Reactor #2 was issued Sept. 23, 1970 and expires July 31, 2030. Reactor #2 is a pressurized water reactor.

Portions of Chesterfield, Darlington and Lee counties are located in the 10-mile Emergency Planning Zone of the facility. A small portion of the Lynches River Swamp in Kershaw County is within this 10-mile zone, therefore, Kershaw County has been included in the planning efforts since 2008. The area is sparsely populated and prevailing wind patterns in the area make it highly unlikely the area would be affected in the event of an incident.

Oconee Nuclear Station

The Oconee Nuclear Station is located 30 miles west of Greenville, near the eastern border of Oconee County and just north of Bridge 183 on the Keowee River. The station is owned and operated by Duke Energy Corporation, headquartered in Charlotte, N.C. Oconee earned the further distinction of being the second nuclear station in the country to have its licenses renewed by the Nuclear Regulatory Commission for an additional 20 years. All U.S. reactors are initially licensed by the NRC for 40 years.

In operation since 1973, the Oconee Nuclear Station has three nuclear reactors with a power production capability of 2,538 megawatts. It is a vital component of the Keowee-Toxaway Complex which includes two hydroelectric developments. The license for Reactor #1 was issued Feb. 6, 1973 and expires Feb. 6, 2033. The license for Reactor #2 was issued Oct. 6, 1973 and expires Oct. 6, 2033. The license for Reactor #3 was issued July 19, 1974 and expires July 19, 2034. All three reactors are pressurized water reactors.

For emergency planning and response purposes, parts of Oconee and Pickens counties are located within the 10-mile Emergency Planning Zone of the station. Prevailing winds in the area make it most likely that residents in the Pickens County portion of the EPZ would be affected by an accident with off site considerations; however, shifting wind conditions could affect Oconee residents downwind of the site.

Savannah River Site

The Savannah River Site, which has historically played a role in the production of tritium and plutonium for national defense, continues to execute missions that involve the processing, disposition and storage of nuclear materials.

The Savannah River Site is located in parts of Aiken, Allendale and Barnwell counties. Historically, facilities at the 310 square mile site were used to produce materials, primarily plutonium and tritium, for national defense. The site continues to play a role in the processing of tritium for national defense; other missions focus on the disposition of plutonium and radioactive waste along with handling, processing and storage of a variety of nuclear materials. The site also hosts the Savannah River Nuclear Laboratory; whose mission includes research and development on nuclear materials.

The current mission also includes extracting, loading, and recycling tritium reservoirs to support the U.S. nuclear stockpile; environmental cleanup including soil and groundwater; construction and operations of plutonium disposition facilities; and construction and operations of radioactive liquid waste facilities.

For emergency planning and response purposes the 10-mile Emergency Planning Zone includes Aiken, Allendale and Barnwell counties.

V.C. Summer Nuclear Station

The V. C. Summer Nuclear Station is located 26 miles north of Columbia, at the southern end of the Monticello Reservoir in western Fairfield County.

The station began operation in Jan. 1984 and has one nuclear power reactor with an electric power generation capability of 966 megawatts. The license for Reactor #1 was issued Nov. 12, 1982 and expires Aug. 6, 2042. The reactor is a pressurized water reactor.

For emergency planning and response purposes, portions of Fairfield, Lexington, Newberry, and Richland counties are located within the 10-mile Emergency Planning Zone of the facility.

Vogtle Electric Generating Plant

The Vogtle Electric Generating Plant is located 34 miles southeast of Augusta, G.A., in the eastern portion of Burke County.

Vogtle has two nuclear reactors that become operational in 1987 with a combined power generating capability of 2,450 megawatts. The license for Reactor #1 was issued March 16, 1987 and expires Jan. 16, 2027. The license for Reactor #2 was issued March 31, 1989 and expires Feb. 9, 2029. Both reactors are pressurized water reactors.

The State of South Carolina maintains emergency plans for this facility since a small, low population area located within its 10-mile Emergency Planning Zone. For emergency planning and response purposes, small portions of Aiken, Allendale and Barnwell counties are located in the 10-mile EPZ.

DHEC's Role in Response

The South Carolina Department of Health and Environmental Control (SCDHEC or DHEC) is tasked with providing radiological technical assistance, emergency planning and advice to the Governor's Office and the South Carolina Emergency Management Division (SCEMD). This important role in the state's ability to respond to radiological emergencies requires both technical responses, during an actual emergency, and extensive day-to-day planning and liaison work.

DHEC created the Nuclear Response and Emergency Environmental Surveillance (NREES) section to provide the department's response to radiological emergencies.

The NREES responsibilities assigned to this section include:

- Maintaining a radiological hazard assessment capability and provide radiological technical support, coordination and guidance for the state.
- Preparing and updating supporting technical radiological emergency response plans.
- Provide for a 24-hour accident notification system.
- Provide protective actions guides as well as recovery and re-entry guidelines.
- Provide technical representative to industry and county and state government.
- Obtain and coordinate emergency radiological assistance from the federal government, other state and private industry.
- Direct monitoring efforts in the 10-mile emergency planning and the 50-mile ingestion pathway zones.
- Coordinate monitoring at shelters and reception centers, and of emergency workers and vehicles.
- Provide technical advice on decontamination and disposal of contaminated materials.
- Provide water supply information required for sampling and monitoring and respond to radioactive waterborne releases that threaten public water supply.
- Provide radiological monitoring training to technical personnel, and members of local and state government.

- Participate in annual training programs at nuclear facilities.
- Assist in the development and coordination of, and participate in, nuclear facility emergency exercises.
- Coordination with Clemson Extension Service on crop and other agricultural information. Provide advice on protection recovery and re-entry.

For more information on DHEC's response to radiological and nuclear emergencies, contact:

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DHEC: Radiation Basics

Background

Radioactive materials are composed of atoms that are unstable. An unstable atom gives off its excess energy until it becomes stable. The energy emitted is radiation. Each of us is exposed to radiation daily from natural sources, including the Sun and the Earth. Small traces of radiation are present in food and water. Radiation also is released from man-made sources such as x-ray machines, television sets, and microwave ovens. Radiation has a cumulative effect. The longer a person is exposed to radiation, the greater the effect. A high exposure to radiation can cause serious illness or death.

Radiation Basics

What is an atom?

Everything and everyone in the universe, is composed of different types of matter with different chemical elements. The smallest pieces of each of those elements are called "atoms". Atoms are so tiny that they can be seen only with very powerful microscopes. But the atoms make up the very core of every substance in the universe.

Are all atoms alike?

Atoms can be very different. They are unique for each element, such as gold, silver, lead, tin, radium, carbon, and thorium. Our bodies are made mostly of hydrogen, carbon, oxygen, and calcium atoms. Air is made of oxygen, hydrogen, nitrogen, and other atoms. Water is hydrogen and oxygen. Even man-made things like cars, computers and cell phones are made of some type of metal and plastic atoms. Just like some atoms carry specific characteristics – that cause them to become chemicals like chlorine – others carry different characteristics making them Uranium or Potassium. Both Potassium and Uranium have naturally radioactive characteristics.

What is radiation?

Everything and anything…Radiation is a form of energy and it is present all around us all of the time. The term radiation is a broad term used to describe such things as heat, light, radiowaves, microwaves and other familiar forms of energy. Different types of radiation exist; some have more energy than others.

When radiation is given off from an atom, it is moving at very high speeds – faster than can be seen by the naked eye. So something that is radioactive means it is giving off a lot of "energy". Even something natural, like fruit, can be radioactive.

Radiation is colorless, odorless, tasteless, and invisible. It is a type of energy in the form of particles or electromagnetic rays that are given off by atoms. The type of radiation we are concerned with, during radiation incidents, is “ionizing radiation”.

What is radioactivity?

Sometimes the center of an atom (its nucleus) has too much energy in it. An atom cannot hold this energy forever. Sooner or later, the atom must get rid of the excess energy and return to its normal (stable) state. Atoms with too much energy in their nuclei, the center of the atoms, are called "radioactive". They get rid of their excess energy by releasing radiation through energy. Some radioactive atoms exist naturally; others are made artificially.

When fruits rot or vegetables ripen they are going through a very slow radioactive change – one that occurs naturally. Radioactive atoms give off tiny pieces of themselves in an attempt to get rid of excess energy. The radiation can be in the form of particles moving at high speeds, or pure energy. Anything that undergoes the process of changing is actually going through a radioactive change.

Thinking about the sun's effect is a good way to think about how radiation and radioactivity affect our bodies. When the rays from the sun reach our bodies they deposit their energy and the warmth we feel is the radiation and energy from the sun's rays. A suntan or sunburn is the effect of the sun's radiation being deposited onto our skin. When the radiation collides with something, they deposit some – or all – of that energy in the thing with which they have collided. When radiation from a radioactive atom penetrates an object, it deposits its energy in that object just like the sun's rays' deposit energy in our bodies. Over a lifetime, too much exposure to the sun can have negative health effects such as the development of skin cancer.

What is ionizing radiation?

It is a type of radiation that has enough energy to break chemical bonds (knocking out electrons). Materials that give off, or emit, ionizing radiation have enough strength to actually <u>change</u> <u>cells</u> and/or change the <u>nature</u> <u>of</u> <u>objects</u> on the <u>atomic</u> <u>level</u>.

What types of ionizing radiation are there?

Three different kinds of ionizing radiation are emitted from radioactive materials: alpha (helium nuclei); beta (usually electrons); x-rays and gamma (high energy, short wave length light).

- **Alpha particles** are dense and stop after traveling only a few inches in air. Alpha particles can be stopped by a thin sheet of cloth or a sheet of paper. However, alpha particles (also referred to as alpha emitting materials) pose serious health dangers primarily if they are inhaled or ingested (breathed in or eaten).

- **Beta particles** can travel farther in air, as they are less dense than alpha particles. Beta particles (or beta emitting material) can easily be stopped by aluminum foil or human skin. Unless Beta particles are ingested or inhaled they usually pose very little danger to people.

- **Gamma rays, photons rays and x-rays** are very penetrating. They pose a large danger to people because of they are able to penetrate, or even pass completely through, the human body. Gamma rays and x-rays can go through many feet of air or several inches of lead/concrete protection (shielding).

What is non-ionizing radiation?

Non-ionizing radiation is a type of radiation that has a long wavelength. Long wavelength radiations do not have enough energy to "ionize" materials (knock out electrons). Some types of non-ionizing radiation sources include radio waves, microwaves produced by cellular phones, microwaves from microwave ovens and radiation given off by television sets.

Can radioactivity be neutralized?

Currently there is no way in which we can neutralize radioactivity. The best we can do is transfer radioactive material to some place safe and then wait for it to decay. Decay is usually measured or discussed in reference to a material's "half-life."

What is radioactive decay?

It is the process where radioactive materials disintegrate as they release radiation.

What is half-life?

Half-life is the amount of time it takes for half of the atoms in a sample of radioactive material to decay. For example, a sample of 1,000 atoms of a radioactive material with a half-life of one year will have only 500 atoms of the material left after one year and by the end of the second year there will only be 250 atoms of the material left.

Radiation Measurements

What is a "unit"?

A "unit" is simply a way to express certain measurements. For example, an "inch" is a unit of length. A "second" is a unit of time. A "pound" is a unit of weight. It is the same with radiation.

What is a "dose"?

A "dose" is the amount of radiation, or energy, absorbed by a person during a given amount of time. Units of dose are used to describe the potential for radiation damage to body tissues.

What is a "rem" or "Rem"?

A "rem" is a unit of "radiation dose" or the way we describe how much radiation "energy" is deposited into someone or something. If our body absorbs radiation energy equivalent to about two-millionths (2/1,000,000) of a "calorie", we say we have received a "rem" of radiation dose.

So then what is a "calorie"?

Calories are another measurement of energy. A calorie is defined as the amount of energy it takes to raise 1 gram of water (about 1 cubic centimeter or about a thimble full) one (1) degrees Celsius. One calorie is equal to 4.186 kilojoules.

How much energy is in a "joule" or a "kilojoule"?

A joule, kilojoules or megajoule are all measurements of energy. A joule, the smallest of the three, is not much energy at all. If you had a joule of energy in your battery, your typical flashlight would stay on for about 0.1 seconds. A kilojoules, which = 1,000 joules, would keep that light burning for 100 seconds, and a megajoule would have it burning for 100,000 sec (about 28 hours).

So then is a "rem" a large radiation dose?

It can be when compared to the types of radiation doses people commonly receive every day. Every day people receive small amounts of natural background radiation – from the sun, the ground, the water, even the food we eat. Compared to those amounts a "rem" is a substantial dose... just like a "ton" is a substantial weight when we're talking about pieces of notebook paper, and a "mile" is a substantial length when we're talking about inches on a ruler.

Are there smaller units than a Rem?

Yes, the "millirem" – abbreviated mRem. A millirem is one-thousandth (1/1,000) of a Rem. An even smaller, but frequently more practical unit is the "microrem" – abbreviated μRem – which is one-millionth (1/1,000,000) of a Rem. Beginning on page **13** of this document you can find a list of common radiation exposures, annual average radiation exposures and how much radiation is generated by each activity.

What does the term "rate" mean?

A "rate" is the amount of any unit of measurement that occurs over some specific time period. For example, "miles per hour" is a rate of speed, or the distance traveled in one hour. Likewise, "millirems per hour" is a dose rate, or the amount of radiation energy deposited in a one-hour period of time.

What is a "curie"?

A "curie" is a unit of radioactivity. It tells us how many radioactive atoms - within any group of atoms – are giving off radiation. Just like a "ream" of paper in a drawer tells us that there are 500 sheets in the drawer, a curie of radium in a container tells us that there are 37,000,000,000 radium atoms giving off radiation.

Is a curie a lot of radioactivity?

Yes. Compared to the amount of naturally occurring radioactivity in our bodies, it is a very large amount -- about ten million times larger. Therefore, it is sometimes more convenient to use units like "picocuries". A picocurie is one trillionth of a curie.

Is there an easy way to distinguish "millirems" from "picocuries"?

Yes there is. A fireplace with a nice fire burning in it is a good way to explain the difference between these two terms. In a fireplace, the burning wood or coals radiate heat. In this case, the amount of burning wood/coal (fuel) in the fireplace is similar to the number of picocuries of radioactivity. The amount of heat (energy) given off by the fireplace is similar to the number of millirems of radiation energy.

Is there another example that gives us an equivalent to the term "picocurie"?

Yes. This time, picture yourself sitting in a stadium watching a sporting event. When something exciting happens, you are likely to see a lot of flashes coming from the stands where people are taking pictures.

If you could somehow count the number of flashes over a particular time period - say 10 minutes - you would know the "flash rate" from all the cameras that are in the stadium. This measurement is similar to how the amount of radioactivity - in a collection of atoms - is determined. In this case we count the bursts of radiation (flashes) being given off by the atoms (cameras) per unit time (10 minutes). When we see 22 bursts in 10 minutes, we know we have measured a picocurie of radioactivity (22 flashes in 600 seconds or 11 flashes in 5 minutes).

How does the term "millirem" fit into this example?

Let's say that while you are in the stadium, you take out your light meter and measure how much light is coming from the flashes in the stand over a one-hour period. The amount of light measured by the meter is a measurement of the amount of "energy" coming from the cameras in the stadium. This measurement is similar to the radiation dose (energy) from a collection of atoms (cameras) per unit time (one hour). The units of this measurement would be "millirems per hour".

What does the term "picocurie per gram" mean?

This refers to the amount of radioactivity in a solid substance. Picture a one-ton batch of concrete that contains 1,000 pounds of gravel, 500 pounds of cement, and 500 pounds of water. To describe this particular mix of concrete, one might say it contains "500 pounds per ton" of cement. This means that for every pound of concrete, there will also be a quarter of a pound of cement present. Similarly, if you wished to describe the amount of radioactivity that typically exists in soil throughout the United States, you would say that it contains about "one picocurie per gram" of radium, one picocurie per gram of thorium, and a host of other radioactive elements. This means that for every gram (about 0.002 pounds) of soil, there will also be one picocurie of radium and one picocurie per gram of thorium present, along with the rest of the radioactive elements commonly found in soil.

What does the term "picocurie per liter" mean?

This refers to the amount of radioactivity in a liter (about a quart) of liquid substance, such as water. Water directly out of the tap contains about 0.01 "picocuries per liter" each of Uranium, Radium, and radioactive Lead. It may also contain between 100 and 400 picocuries per liter of radioactive hydrogen, between 100 and 500 picocuries per liter of radioactive carbon, between 10 and 30 picocuries per liter of radioactive beryllium and a variety of other radioactive elements such as aluminum, chlorine, silicon, lead, bismuth, polonium, and argon. It can contain several hundred to several thousand picocuries per liter of radon gas, particularly if you get your drinking water from a well.

Is there radioactivity in the world around us?

Absolutely. The earth has always been radioactive. Everyone and everything that has ever lived has been radioactive. In fact, the natural radioactivity in the environment is just about the same today as it was at the beginning of the Neolithic Age, more than 10,000 years ago.

Is there radioactivity in our bodies?

Yes. During our lifetime, our bodies harbor measurable amounts (billions) of radioactive atoms. About half of the radioactivity in our bodies comes from Potassium-40, a naturally radioactive form of Potassium. Potassium is a vital nutrient and is especially important for the brain and muscles. Most of the rest of our bodies' radioactivity is from radioactive carbon and hydrogen. We have about 120,000 picocuries of radioactivity in our bodies. These naturally occurring radioactive substances expose our bodies to about 25 "millirem" per year, abbreviated as "mrem/yr" or "mRem/yr".

Most radioactive substances enter our bodies as part of food, water or air. Our bodies use the radioactive as well as the non-radioactive forms of vital elements such as Iodine and sodium. Radioactivity can be found in all foods. As we said before, it is even in our drinking water. In a few areas of the United States, the naturally occurring radioactivity in the drinking water can result in a dose of more than 1,000 millirem in one year.

Sources of Radiation

Are there other sources of natural radiation?

Another type of natural radiation is cosmic radiation given off by the sun and stars in outer space. Because the earth's atmosphere absorbs some of this radiation, people living at higher altitudes receive a greater dose than those at lower altitudes.

In Ohio, for example, the average resident receives a dose of about 40 millirem in one year from cosmic radiation. In Colorado, it is about 180 millirem in one year. Generally, for each 100-foot increase in altitude, there is an increased dose of one (1) millirem per year.

Flying in an airplane increases our exposure to cosmic radiation. A coast-to-coast round trip gives us a dose of about four millirem.

In Ohio, radiation in soil and rocks contributes about 60 millirem in one year to our exposure. In Colorado, it is about 105 millirem per year. In Kerala, India, this radioactivity from soil and rocks can be 3,000 millirem per year, and at a beach in Guarapari, Brazil, it is over 5 millirem in a single hour or 43,800 millirem per year (5 millirem **x** 24 hours **x** 365 days = 43,800 millirem or 43.8 Rem).

If you live in a wood house, the natural radioactivity in the building materials gives you a dose of 30 to 50 millirem per year. In a brick house, the dose is 50 to 100 millirem per year. And, if your home is so tightly sealed that the leakage of outside air into the home is small, natural radioactive gases (radon) can be trapped for a longer period of time and thus increase your dose.

What are naturally occurring sources of ionizing radiation?

They include elements in the soil, naturally occurring radon, naturally occurring Potassium and naturally occurring Uranium mill tailings, and cosmic rays from the sun.

Where do man-made sources of ionizing radiation come from?

The sources include medical sources (x-rays, medical treatments), and from nuclear weapons testing. Some consumer products that contain radioactive materials include: smoke detectors, some watches and clocks (especially older radium dial types), some ceramics (such as old orange-red glazed Fiesta ware), some glass (especially antique glassware with a yellow or greenish color), fertilizer, food, and even gas lantern mantles.

What is the most commonly occurring radionuclide in the human body?

Potassium-40 is the most common. It is found in Potassium-rich foods such as bananas.

So, almost everything is radioactive, right?

Yes, radiation is everywhere. Our bodies, and the world around us, are radioactive. But there is no cause for alarm. These very small but detectable levels of radioactivity are natural. We are exposed to a constant stream of radiation from the sun and outer space. Radiation is in the ground, the air, the buildings we live in, the food we eat, the water we drink, and some of the products we use. The average U.S. resident receives about 620 millirem per year from these natural sources of radioactivity, as well as, from typical man-made medical radiation exposures such as x-rays. Prior to 2009, the average annual exposure was 360 millirem but in 2009 the National Council on Radiation Protection (NCRP) increased their estimates based on studies and surveys that showed an increase in human exposure to radiation and radioactive material. The increase was found to be a result of the increased number of medical procedures and treatments involving radioactive medical products such as MRIs, CAT Scans and nuclear stress tests.

Is any amount of radiation safe?

Some scientists believe that low levels of radiation are beneficial to health (known as hormesis). However, there do appear to be thresholds of exposures for various health effects, for example: at **50 Rem** nausea occurs, at **70 Rem** vomiting occurs, at **400-to-500 Rem** death occurs.

What are some of the most common exposures of/to radiation?

Gastrointestinal series (upper & lower)	➔ **1,400** millirem **per exam**
Cigarette Smoking (average – several packs/day)	➔ **1,300** millirem **per year**
CT Scan (head & body)	➔ **1,100** millirem **per exam**

Nuclear medicine examination of the brain	➔	**650** millirem **per exam**
Average annual background dose to humans	➔	**620** millirem **per year**
Nuclear medicine examination of the thyroid	➔	**509** millirem **per exam**
Barium Enema	➔	**405** millirem **per exam**
Upper gastrointestinal tract series	➔	**245** millirem **per exam**
Radon in average household	➔	**200** millirem **per year**
Dose to members of airline crews	➔	**170** millirem **per year**
Nuclear medicine examination of the lung	➔	**150** millirem **per exam**
Computerized tomography of the head	➔	**110** millirem **per exam**
Plutonium-powered pacemaker	➔	**100** millirem **per year**
Natural radioactivity in your body (120,000 pCi/L)	➔	**40** millirem **per year**
Cosmic radiation	➔	**31** millirem **per year**
Mammogram	➔	**30** millirem **per exam**
Smoking Cigarettes (1 cigarette/day)	➔	**15** to **20** millirem **per year**
Consumer products	➔	**11** millirem **per year**
Using natural gas in the home	➔	**9** millirem **per year**
To spouses of recipients of certain cardiac pacemakers	➔	**7.5** millirem **per year**
Chest X-ray	➔	**6-8** millirem **per exam**
Foods grown on lands (where phosphate fertilizers are used)	➔	**5** millirem **per year**
Road construction material	➔	**4** millirem **per year**
Dental X-ray	➔	**3** millirem **per exam**
The use of gas mantles	➔	**2** millirem **per year**
Domestic water supplies	➔	**1** to **6** millirem **per year**
Living near a nuclear power station	➔	**1** millirem **per year**
Air travel (every 2006 miles)	➔	**1** millirem **per trip**
(Cross-country flight)	➔	**2** millirem **per trip**
Television receivers	➔	**1** millirem **per year**
Eating one-half pound of Brazil nuts	➔	**0.5** millirem **per bag**
Combustible fuels (i.e.-coal, natural gas, liquefied petroleum)	➔	**0.3** millirem **per year**
Drinking a quart of Gatorade each week	➔	**0.2** millirem **per year**
Sleeping with one's spouse (or "significant other")	➔	**0.1** millirem **per year**

Sources: - U.S. DOE Oak Ridge
- 2004 DOE Annual Site Environmental Report Summary

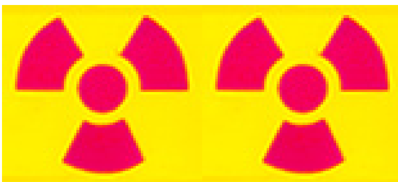
Compact fluorescent light bulb (Krypton-85)	➔	**15,000** p/Ci **per year**
Salt Substitute	➔	**2,400** p/Ci **per teaspoon**
Airborne radioactivity from nuclear power plants	➔	**550** p/Ci **per year**
Common lawn & garden fertilizer	➔	**30** to **50** p/Ci **per 50-lb. bag**
Loose leaf of spinach	➔	**8** p/Ci **per salad**
Bananas	➔	**4** p/Ci **per banana**
Waterborne radioactivity from nuclear power plants	➔	**0.6** p/Ci **per year**

Sources: - KAPL Analysis, 2000
- NCRP Report # 95, Radiation Exposure from Consumer Products and Miscellaneous Sources, 1987
- U.S. NRC Report NUREG/CR-2907, Vol. 14, Annual Report 1993

Is a radiation dose of 620 millirem (or 0.62 Rem) in a year harmful?

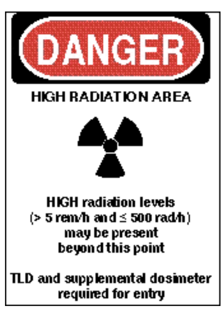
No. No effects have ever been observed at doses below 5,000 millirem (5 Rem) delivered over a one-year period. In fact, effects seen when humans are exposed to 100,000 millirem (100 rem) over a short time period are temporary and reversible. It takes a short-term dose of well over 500,000 millirem (500 rem) to cause a fatality.

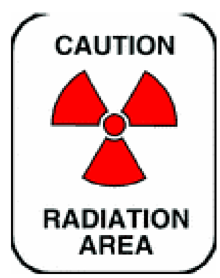
Radiation Signs and Symbols




The symbol above is called a tri-foil and it is the international symbol for radiation. The symbol can be magenta or black, on a yellow background. This sign is posted where radioactive materials are handled, where radiation-producing equipment is used, or where a radiation exposure is possible. This sign is used as a warning to protect people from being exposed to radioactivity or contaminated by radioactive material.

Some examples of signs using this tri-foil symbol are shown below. You might see the radiation symbol in a hospital where radioactive medicine is used, or in a university, or research facility. In a radiation incident, the signs would be posted where radioactive materials have been found and a site clean up is taking place.





How do I minimize my radiation exposure?

There are key three components to consider in minimizing your radiation exposure. They are <u>time</u>, <u>distance</u>, and <u>shielding</u>.

Time: By limiting the amount of time you spend near the radiation source you can reduce the amount of radiation exposure that you will receive.

Distance: The greater the distance between you and the radiation source, the less radiation exposure you will receive.

Shielding: The more heavy and denser the material between you and the source of the radiation the better. The shielding will block much of the radiation from reaching you.

For more information on radiation and DHEC's role in response, contact:

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DHEC: Radiation Health

Contamination vs. Exposure

What is radioactive contamination?

Radioactive contamination is when a person or object has radioactive material either internally or externally. Radioactive materials released into the environment can cause air, water, surfaces, soil, plants, buildings, people or animals to become contaminated.

What is external contamination?

External contamination on humans occurs when radioactive material, in the form of dust, powder, or liquid, comes into contact with a person's skin, hair, or clothing (any contact outside of the body).

What is internal contamination?

Internal contamination occurs when people swallow or breathe in radioactive materials or when these materials enter the body through an open wound or are absorbed through the skin (any thing introduced into the body). Some types of radioactive materials stay in the body and are deposited in different body organs. Other types are eliminated from the body in blood, sweat, urine, and feces.

What is radiation exposure?

When a person is exposed to some types of ionizing radiation the energy can penetrate the body. For example, when a person has an x-ray, they are exposed to radiation.

How can an exposure occur?

People are exposed to small amounts of radiation every day. This radiation comes from both naturally occurring sources and man-made sources.

What types of exposure occur?

Exposures can be either internal or external. Internal exposures occur when radioactive material is taken into the body through breathing, eating, drinking, absorption through the skin, or through cuts in the skin. External exposure refers to radioactive material that is deposited anywhere (except internally) that it is not supposed to be, such as on an object or on a person's skin.

How does contamination differ from exposure?

A person can be exposed to radiation and not become contaminated. Take an x-ray for example. An x-ray exposes parts of the body to radiation so that an internal picture can be taken – so that we can know what is going on inside. While an x-ray exposes you to radiation, there is nothing "left over" on the surface of the skin or body after the x-ray is over.

Contamination means you've come in direct contact with something radioactive and part of that radiation is left on you or you skin or clothing. The contamination can be removed, through washing (also known as decontamination), but until it does anything you have touched – with that contaminated body part – will get some on that contamination on it. It is similar to touching wet paint and then touching another surface. You will carry some of that wet paint with you to the next surface. The paint will stay on you and those surfaces until it is removed.

Radioactive contamination emits radiation. If a person is contaminated, they will continue to be exposed to radiation until the contamination is removed.

How is radioactive contamination spread?

People who are externally contaminated with radioactive material can contaminate other people or surfaces that they touch. People who are internally contaminated can expose people near them to radiation from the radioactive material inside their bodies. The body fluids (blood, sweat, urine) of an internally contaminated person can contain radioactive materials. Coming in contact with these body fluids can result in contamination and/or exposure (through contact with contaminated urine or feces).

How could your home become contaminated?

People who are externally contaminated can spread the contamination by touching other surfaces, sitting in a chair, or even walking through a house. Homes can also become contaminated with radioactive materials in body fluids from internally contaminated people.

How can exposure or contamination happen?

Man-made radioactive materials could be released into the environment in the following ways:

- An accidental release from a medical or industrial device.
- A nuclear power plant accident.
- An atomic bomb explosion.
- Nuclear weapons testing.
- An intentional release of radioactive material as an act or terrorism.

How is radioactive material contamination cleaned up?

Techniques include sandblasting buildings to remove the layers of contamination and removing the layers of contaminated soil and trucking it away to a radioactive waste disposal site. **We cannot <u>completely</u> <u>eliminate</u> radioactivity**. We can only transfer radioactivity from one place to another. Then we must wait until the radioactive materials decay.

How can I limit the chances of becoming contaminated?

When safe, or directed to do so, get out of the immediate area of the radiation incident. Go inside the nearest safe building or to the area to health officials or emergency management officials direct you.

Remove the outer layer of your clothing. If radioactive material is on your clothes, getting it away from you will reduce the external contamination and decrease the risk of internal contamination. It will also reduce the length of time that you are exposed to radiation.

Place the clothing in a plastic bag or leave it in an out-of-the-way area. Keep people away from it to reduce their exposure to radiation. Keep cuts and abrasions covered when handling contaminated items to avoid getting radioactive material in them.

Wash all of the exposed parts of your body using lots of soap and water to remove contamination.

If medical authorities determine that internal contamination may have occurred, you may be able to take medication to reduce the radioactive material in your body.

Be on the lookout for information. Once health officials assess the scene and the damage, they will be able to tell people whether or not radiation was involved in the incident.

How do I minimize my radiation exposure?

There are key three components to consider in minimizing your radiation exposure. They are <u>time</u>, <u>distance</u>, and <u>shielding</u>.

Time:	By limiting the amount of time you spend near the radiation source you can reduce the amount of radiation exposure that you will receive.
Distance:	The greater the distance between you and the radiation source, the less radiation exposure you will receive.
Shielding:	The more heavy and denser the material between you and the source of the radiation the better. The shielding will block much of the radiation from reaching you.

<u>Health Effects of Exposure</u>

What happens when people are exposed to radiation?

Radiation can affect the body in many ways, and the health effects may not be apparent for many years. These effects include mild symptoms, such as skin reddening, to serious effects such as cancer and death. These effects are dependant upon the amount of radiation absorbed by the body (the dose), the type of radiation, whether or not the exposure was internal or external, and the length of time the person was exposed. Any living tissue in the human body can be damaged by ionizing radiation. The body attempts to repair the damage, but sometimes the damage is too severe or widespread. Mistakes can also be made in the body’s natural repair process as it tries to repair the damage caused by the radiation. These mistakes are referred to as mutations.

What is prenatal radiation exposure?

It is the exposure of an unborn baby to radiation. This can occur when the mother's abdomen is exposed to radiation, either externally or internally. Also, radioactive materials may enter the mother's bloodstream if a pregnant woman accidentally swallows or breathes in radioactive materials. From the mother's blood, radioactive materials may pass through the umbilical cord to the baby.

Unborn babies are less sensitive during some stages of pregnancy than others. However, unborn babies are particularly sensitive to radiation during their early development, between the second and fifteenth weeks of pregnancy. The health consequences can be severe, even if radiation doses are too low to make the mother sick. Such consequences can include stunted growth, deformities, abnormal brain function, or cancer that may develop sometime later in life. The radiation dose to the unborn baby is usually lower than the dose to the mother for most radiation exposure events.

Pregnant women should consult with their doctors if they have any concern about radiation exposure to their unborn baby.

What are the risks of other long-term health effects?

There is the possibility of mutations in fetuses and genetic effects in children and adults.

What are the possible genetic effects due to radiation exposure?

Genetic effects are mutations that can be passed from parent to child or mutations that occur in the person exposed. They can include: stunted growth, small head/brain size, developmental disabilities and childhood cancers.

How are radiation exposure victims medically treated?

Treatment of a victim, within the first six-weeks to two-months after exposure, is vital. Only once the type of radioactive material is determined, the material to which the victim was exposed, can the treatment take place. Treatment always depends on the type of material, on the way in which the victim was exposed or contaminated and on the length of time the victim was exposed to the material. There is no "one-size-fits-all" treatment for all exposures to radiation.

Medical personnel will treat victims for physical injuries first (such as cuts, broken bones, trauma, hemorrhage and shock, etc.). Open wounds are usually cleaned to remove any bits of radioactive materials that may be in them. Amputation of limbs may occur if a wound is highly contaminated and recovery of its function is not likely.

If radioactive material is ingested, treatment is given to reduce absorption into the body and enhance body's natural elimination processes (excretion and elimination). It can include stomach pumping or giving the victim laxatives or aluminum antacids.

If radioactive material has gotten into internal organs and/or tissues, treatment includes giving the patient blocking and diluting agents, such as Potassium Iodide, to decrease absorption into the body. Other chemicals such as ammonium chloride, diuretics, expectorants and inhalants are given to a patient to force the body to release the harmful radioactive materials. Other treatments involve chelating agents, which, when ingested, bind with some radioactive metals to form a stable material that is more easily removed from the body through the kidneys.

In the event you suspect you have been exposed to radiation, **DO NOT ATTEMPT TO TREAT YOURSELF**. See a doctor immediately.

Is any amount of radiation safe?

Some scientists believe that low levels of radiation are beneficial to health (known as hormesis). However, there do appear to be thresholds of exposures for various health effects, for example:

- Up to **100 Rem**, there remains little to no lasting effect.
    - At **50 Rem** nausea may occur, but there are no lasting effects.
    - At **70 Rem** vomiting may occurs, but again there are few, if any, lasting effects.
- Between **300-to-500 Rem**, radiation sickness can occur.
    - Mild symptoms include: fatigue, loss of appetite, severe nausea, vomiting and fever.
    - Severe symptoms include: fatigue, loss of appetite, severe nausea, vomiting, fever, diarrhea, inflamed mouth and throat and hair loss.
- At **600 Rem,** death occurs.

* Examples are based on adult exposure. Children, the elderly, and those with compromised immune systems, are more susceptible to excessive radiation exposure and may show more serious symptoms at lower levels of exposure.

What is radiation sickness?

Radiation sickness, known as acute radiation syndrome (ARS), is a serious illness that occurs when the entire body (or most of it) receives a high dose of radiation, usually over a short period of time.

People exposed to radiation will get ARS only if:
- The radiation dose was high.
- The radiation was able to reach internal organs.
- The person’s entire body (or most of it) received the dose.
- The radiation was received in a short time, usually within minutes.

The first symptoms of ARS typically are nausea, vomiting, and diarrhea. These symptoms will start within minutes to days after the exposure. The symptoms may come and go. The person usually looks and feels healthy for a short time, after which he or she will become sick again with loss of appetite, fatigue, fever, nausea, vomiting, diarrhea, and possibly even seizures and coma. This stage may last from a few hours up to several months.

People with ARS usually have some skin damage that can start to show within a few hours after exposure. This damage can include swelling, itching, and redness of the skin (like a bad sunburn). There can also be hair loss, nausea, and diarrhea. As with the other symptoms, the skin may heal for a short time, followed by the return of swelling, itching, and redness days or weeks later. Complete healing of the skin may take from several weeks to a few years depending on the radiation dose to the skin.

The chance of survival for people with ARS decreases with increasing radiation doses. Most people who do not recover from ARS will die within several months of exposure. The cause of death in most cases is the destruction of the person's bone marrow, which results in infections and internal bleeding. For the survivors of higher doses, the recovery process may last from several weeks to two years.

If a radiation emergency occurs that exposes people to high doses of radiation in a short period of time, they should immediately seek medical care from their doctor or local hospital.

How do we know radiation causes cancer?

We have learned through observation. Scientists didn't understand that there were any health effects associated with radioactive materials when people first began working with them. As the use of radioactive materials and reports of illnesses became more frequent, scientists noticed a pattern to the illnesses. People working with radioactive materials and x-rays developed particular types of uncommon medical conditions. Among the best-known long-term studies are those of Japanese atomic bomb blast survivors, other populations exposed to nuclear testing fallout (natives of the Marshall Islands for example), and Uranium miners.

Aren't children more sensitive to radiation than adults?

Yes, because children are growing more rapidly, there are more cells dividing and a greater opportunity for radiation to disrupt the process. Fetuses, depending on their stage of development, can also be highly sensitive to radiation.

What are the possible health effects that an unborn baby could experience when exposed to ionizing radiation?

During the first two weeks of pregnancy, the radiation-related health effect of greatest concern is the death of the baby. Of the babies that survive, some will have birth defects related to the exposure, regardless of how much radiation they were exposed to.

Large radiation doses to the unborn baby during the stages of development (between the second and 15th weeks of pregnancy) can cause birth defects, especially to the brain. Babies exposed to the atomic bombs dropped on Hiroshima and Nagasaki during the 8th to15th week stage of pregnancy were found to have a high rate of brain damage that resulted in lower IQ and even severe mental retardation. They also suffered stunted growth (up to 4% shorter than average people) and an increased risk of other birth defects.

Between the 16th week of pregnancy and birth, health effects due to radiation exposure are unlikely unless the unborn baby receives an extremely large dose of radiation. In the 16th to 25th week of pregnancy, health consequences similar to those seen in the 8th to 15th week could occur, but only when the doses are extremely large (more than the equivalent of about 5,000 chest x-rays received at one time). At this dose level, the mother could also be showing signs of acute radiation syndrome.

After the 26th week of pregnancy, the radiation sensitivity of the unborn baby is similar to that of a newborn. Unborn babies exposed to radiation during this stage of pregnancy are no more sensitive to the effects of radiation than are newborns. This means that birth defects are not likely to occur, and only a slight increase in the risk of having cancer later in life is expected.

Do chemical properties of radioactive materials contribute to radiation health effects?

The chemical properties of a radionuclide can determine where health effects occur. To function properly many organs require certain elements. The organs cannot distinguish between radioactive and non-radioactive forms of the element and the body will try to absorb or accumulate one just as quickly as the other. For example:

- Radioactive Iodine concentrates in the thyroid. The thyroid needs Iodine to function normally. As a result, radioactive Iodine contributes to thyroid cancer more than any other types of cancer.

- Calcium, Strontium-90, and Radium-226 have similar chemical properties. The result is that Strontium and Radium tend to collect in Calcium rich areas of the body, such as the bones and teeth. Therefore, the Strontium-90 and Radium-226 can contribute to bone cancer.

What is the cancer risk from radiation? How does it compare to the risk from other sources?

Currently estimates are that overall, if each person in a group of 10,000 people exposed to one (1) Rem of ionizing radiation, in small doses over a life time, we would expect five or six more people to die of cancer than would otherwise. In this group of 10,000 people, we can expect about 2,000 to die of cancer from all non-radiation causes.

For more information on DHEC's response to radiological health and nuclear emergencies, contact:

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DHEC: How Nuclear Power Plants Work

Basic Information

Nuclear power plants use the heat generated from nuclear fission in a contained environment to convert water to steam. The steam powers generators to produce electricity. Nuclear power plants produce about 20 percent of the nation's power. Nearly three million Americans live within 10 miles of an operating nuclear power plant.

Nuclear power plants are similar in operation to fossil plants. The difference is the fuel. In a nuclear power plant, Uranium – a naturally occurring ore that is enriched through a man-made process – is used. Steam is generated through fission instead of burning oil, gas or coal. Nuclear power plants do not burn any fuel, so there are no pollutants released into the air. The process works like this:

Description

Stage 1: Tiny parts of the Uranium, known as atoms, are made to split, a process called "fission".

Stage 2: During fission, even smaller particles of the atom, called neutrons, are released at high rates of speed.

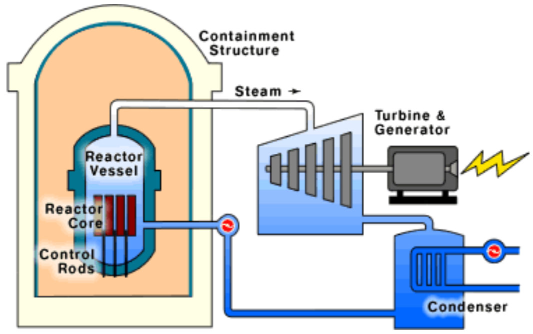
Stage 3: The neutrons strike more Uranium atoms, resulting in the release of heat needed to generate electricity.

The United States Nuclear Regulatory Commission (USNRC or NRC) regulates commercial nuclear power plants that generate electricity. There are several types of these power reactors. Only the Pressurized Water Reactors (PWRs) and Boiling Water Reactors (BWRs) are in commercial operation in the United States. Currently, the 104 nuclear power plants (69 PWRs and 35 BWRs) generate about 20% of the country's electric power use.

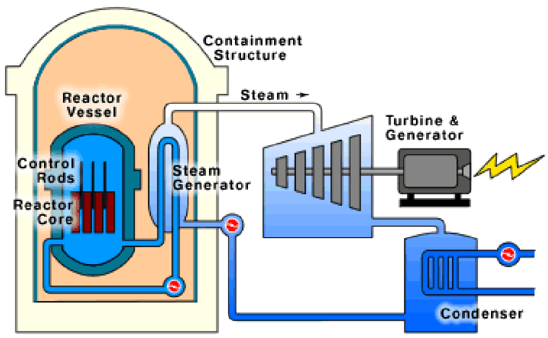
Although the construction and operation of these facilities are closely monitored and regulated by the USNRC, accidents are possible. An accident could result in high levels of radiation that could affect the health and safety of the public living near the nuclear power plant.

Types of Nuclear Power Plants

There are two types of nuclear power reactors: Boiling Water Reactors and Pressurized Water Reactors. In total, the state of South Carolina is home to seven reactors; two are located at the Catawba Nuclear Station, one is located at the H.B. Robinson Nuclear Plant, three are located at the Oconee Nuclear Station and one is located at the V.C. Summer Nuclear Station. All seven reactors are Pressurized Water Reactors (PWRs). The Vogtle Electric Generating Plant is home to two additional pressurized water reactors.**Boiling Water Reactors (BWRs)** boil water so that it is converted to steam. The steam drives a turbine connected to a generator before being recycled back into water by a condenser and used again in the heat process.



Pressurized Water Reactors (PWRs) keep water under pressure so that it heats up but does not boil. Water from the reactor and water in the steam generator never mix.



For more information:

USNRC Nuclear Power Reactors
http://www.nrc.gov/reactors/power.html
USNRC Boiling Water Reactors
http://www.nrc.gov/reactors/bwrs.html
USNRC Pressurized Water Reactors
http://www.nrc.gov/reactors/pwrs.html

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