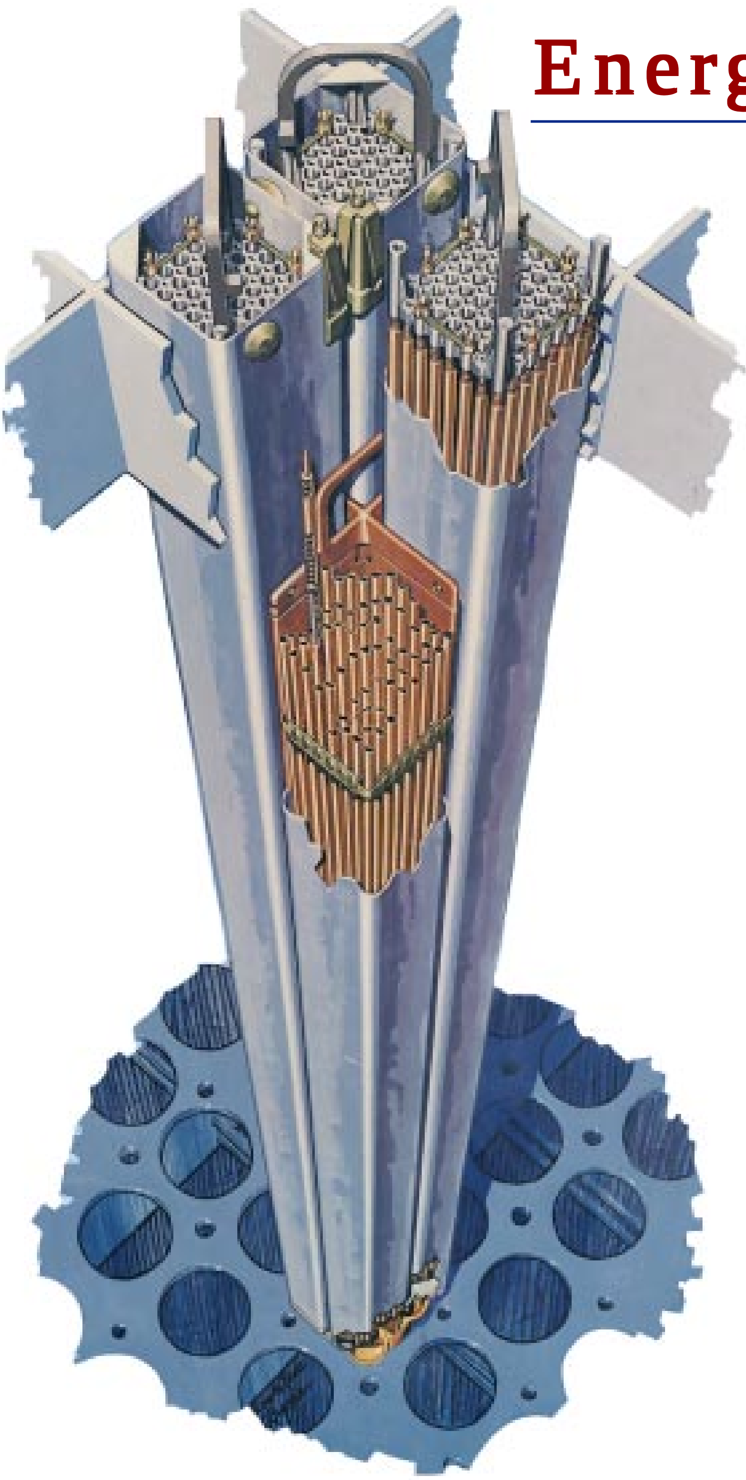
Susquehanna Nuclear Energy Guide



Introduction

PPL has a responsibility to operate the Susquehanna nuclear power plant safely. At Susquehanna, public health and safety take precedence over all other factors in decisions about plant operations.

This concern for safety is a key element in the plant's design, operating procedures and training programs for plant workers. In addition, PPL has in place a detailed emergency response plan that is tested regularly with the cooperation of municipal, county, state and federal organizations.

PPL also wants the public to be aware of issues and events that affect the plant. To that end, PPL has developed this guide to provide you with information about the Susquehanna plant – its history, design, operations and emergency plan — as well as basics about nuclear energy and radiation.

Susquehanna plant tours and nuclear education programs are available at the Susquehanna Energy Information Center by calling (570) 759-2285 or visiting the center's Web site at *www.pplweb.com/seic*.

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Susquehanna Nuclear Plant - At A Glance

Ownership	PPL Susquehanna LLC	90 percent
	Allegheny Electric Cooperative Inc.	10 percent
Location	On a 2,100-acre site in Salem Township, Luzerne County, about seven miles northeast of Berwick	
Capacity	Two generating units of 1,100 megawatts each	
Generators	Speed	1,800 revolutions per minute
	Voltage	24,000 volts
	Cooling	Stator by water Rotor by hydrogen
Turbines	Type	Tandem compound, six flow
	Steam Temperature	540°F (282°C)
	Steam Pressure	1,000 pounds per square inch
	Steam Flow	14,139,000 pounds per hour
Turbine-Generators	Length	208 feet (63 meters)
Transformers	Capacity	1,214,000 kilovolt-amperes
	Voltage Step-Up	Unit #1 – 230,000 volts Unit #2 – 500,000 volts
	Cooling	Oil
Reactors	Type	Boiling water, direct cycle
	Coolant	Water
	Moderator	Water
	Core Coolant Flow Rate	216,000 gallons per minute
	Feedwater Inlet Temperature	386°F (197°C)
	Steam Outlet Temperature	550°F (287°C)
	Coolant Pressure (inlet)	1,075 pounds per square inch
	Steam Capacity	14,184,000 pounds per hour
	Heat Output	11,741,000,000 British thermal units per hour
Fuel Cores	*Pellets*	
	Material	Uranium dioxide ($U0_2$)
	Enrichment	0.71 to 4.95 percent
	Length	0.413 inch
	Diameter	0.341 inch
	Number	24,300,000 per reactor
	Total Weight, Uranium	135.5 metric tons per reactor
	Rods	
	Material	Zircaloy – 2
	Cladding Thickness	0.024 inches
	Outside Diameter	0.396 inches
	Length	13.57 feet
	Number	69,524 per reactor

Control Blades	Material	Stainless steel tubing
	Neutron Absorber	Boron carbide
	Blade Length	14.4 feet (4.4 meters)
	Blade Width	9.75 inches (24.77 centimeters)
	Number	185 per reactor
Pressure Vessels	Material	Carbon steel clad with stainless steel
	Height	73.5 feet (22.4 meters)
	Weight	750 tons
	Inside Diameter	20.9 feet (6.41 meters)
	Wall Thickness	4 to 9 inches (10 to 23 centimeters)
	Design Temperature	575°F (302.5°C)
	Design Pressure	1,250 pounds per square inch
Containment	Material	Reinforced concrete
	Height	161 feet (49.2 meters) above base slab
	Wall Thickness	6.0 feet (1.83 meters)
	Lining	0.25 inch (6.35 millimeters) steel
	Volume	519,450 cubic feet
	Design Pressure	53 pounds per square inch
Condensers	Material	Stainless steel tubing
	Number of Tubes	81,500
	Tubing Length	616 miles (991 kilometers)
	Condensing Surface	880,000 square feet
	Cooling Water Flow	448,000 gallons per minute
	Cooling Range	35°F (20°C)
Water Supply	Water lost by evaporation in the essentially closed circuit of the cooling system will be replaced from the Susquehanna River. Combined with other water needs of the plant, this make-up amounts to about 0.6 percent of the average river flow.	
Schedule	Application for Construction	Permit April 1, 1971
	Construction Permit issued by Atomic Energy Commission	November 2, 1973
	Commercial Operation	Unit #1 – June 8, 1983 Unit #2 – February 12, 1985
Employment	Permanent Personnel	About 1,000 full-time PPL employees
Cost	$4.1 billion	

Susquehanna Background

Plant Construction Timeline

1970
- PPL announces construction plans for the plant. Coal-fired plants then provided nearly all of PPL's generating capacity.
- The site was chosen for its stable geology, available cooling water from the Susquehanna River, accessible power supply lines to other parts of PPL's service area and convenient highway and rail transportation.

1973
- U.S. Atomic Energy Commission issues construction permit and work begins in November. Bechtel Power Corp. was the primary contractor.
- More than 5,000 people work to design, build and test the plant.

1982
- Unit 1 receives operating license in July and generates its first electricity in November.

1983
- Unit 1 begins commercial service in June.

1984
- Unit 2 receives operating license in March and generates its first electricity in July.

1985
- Unit 2 begins commercial service in February.

General Plant Information

Location
- On a 2,100-acre site in Salem Township, Luzerne County, Pa.
- About seven miles northeast of Berwick, Pa.
- About 25 miles southwest of Wilkes-Barre, Pa.

Ownership
- PPL Susquehanna LLC owns 90 percent of the plant and operates it. Allegheny Electric Cooperative Inc. owns the remaining 10 percent.
- PPL Susquehanna LLC is a subsidiary of PPL Generation LLC, which is a subsidiary of PPL Corp. based in Allentown, Pa. PPL Corp. generates electricity at power plants in the northeastern and western United States; markets energy throughout the United States and Canada; provides energy services for businesses in the mid-Atlantic and northeastern U.S.; and delivers energy to customers in Pennsylvania, the United Kingdom and Latin America.

- Allegheny Electric Cooperative, based in Harrisburg, provides power to member cooperatives in Pennsylvania and New Jersey. Allegheny purchased 10 percent of the Susquehanna plant in 1977.

Operation

- Susquehanna has two boiling water reactors made by General Electric Co.
- Heat is produced by the splitting, or fissioning, of uranium (U^{235}) atoms in the reactors, which makes steam that drives turbine-generators to produce electricity.
- Each unit has a capacity of 1,100 megawatts of electricity; the plant's full output is about 53 million kilowatt-hours a day.

Training

- Susquehanna has an on-site training center with a staff who instruct a curriculum fully accredited by the National Academy for Nuclear Training.
- Control room crews spend one week in six training either in the classroom or on an advanced control room simulator.
- Licensed nuclear reactor operators are requalified every year. Maintenance and technical support complete extensive training for certification in their specialties.

Employment

- During normal operation, about 1,000 full-time employees work at the plant in operations, maintenance, engineering and technical support positions and another 400 work in the Nuclear Department at PPL's Allentown headquarters.
- About 2,000 people work at the plant during refueling outages. Each unit is shut down for refueling every 24 months, during which time one-third of the uranium fuel in the reactor is replaced and other planned maintenance and inspection tasks are completed.

Overview

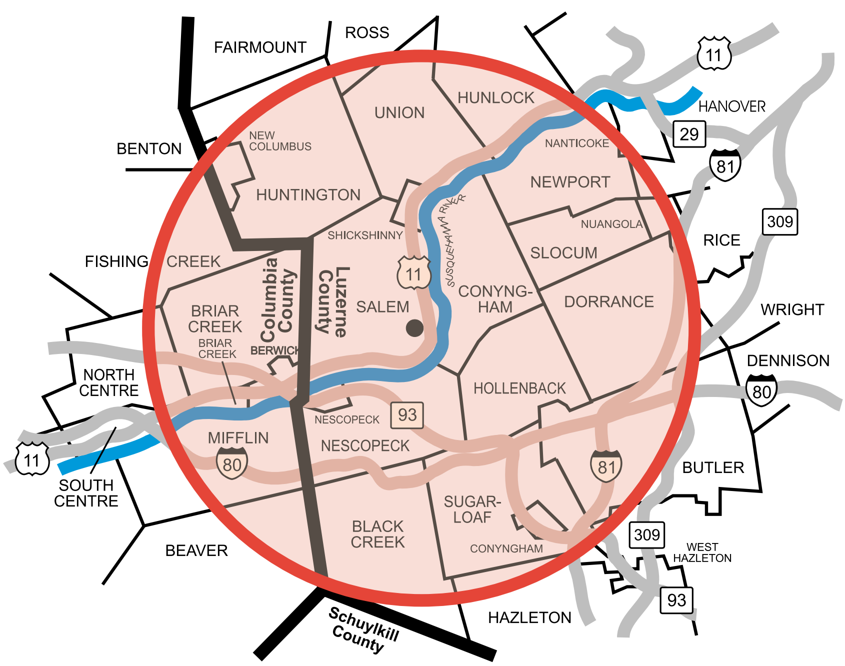
Susquehanna has a large emergency response network consisting of 27 municipalities, county and state governments, school districts, hospitals, fire companies, ambulance and emergency medical services, and federal agencies.

The Nuclear Regulatory Commission has reviewed and approved Susquehanna's emergency plan.

The level of response to an event depends on the potential threat to public health and safety. In any emergency at Susquehanna, PPL has three objectives:

1. Take any necessary actions to end the emergency.
2. Activate the emergency plan to reduce any potential risk to public health and safety.
3. Keep the public informed about events at the plant.

10-Mile EPZ



Public Notification

PPL maintains a network of 112 sirens in the communities around Susquehanna. PPL provided the sirens for use by Luzerne and Columbia county officials in any emergency, nuclear or non-nuclear.

- Luzerne and Columbia are called “risk” counties because they include areas within 10 miles of the plant where residents may be ordered to evacuate in a serious emergency.
- If an emergency requires public action, county officials will sound the sirens in a steady tone for three to five minutes. When area residents hear a steady siren tone, they should turn on a radio or television and tune to an Emergency Alert System station for official information and instructions.
- Some of the sirens are shared with local fire companies. When used for fire company purposes, the sirens sound in a varying tone and there is no need for action by area residents.
- PPL and the counties test the sirens monthly; PPL is responsible for maintaining the sirens.
- In addition to sirens, police, firefighters and volunteers in some areas will drive around with mobile public address systems. For people with special needs, volunteers will go door-to-door to provide help, information and instructions.
- The Emergency Alert System for Luzerne and Columbia counties includes 25 radio stations and two television stations.

Local Emergency Alert System (EAS)

Columbia County	Luzerne County	
WCNR-AM 930	WAZL-AM 1490	WWFH-FM 103.1
WJMW-AM 550	WBAX-AM 1240	WDLS-FM 93.7
WHLM/WFYY-FM 106.5	WILK-AM 980	WSFX-FM 89.1
WKAB-FM 103.5	WILP-AM 1300	WRKC-FM 88.5
WKXP-FM 95.9	WKQV-AM1550	WRGN-FM 88.1
WQKX-FM 94.1	WNAK-AM 730	WMGS-FM 92.9
WBRE Ch. 28	WYCK-AM 1340	WQFM-FM 92.1
	WZMT-FM 97.9	WWSH-FM 102.3
	WKRZ-FM 98.5	WBRE Ch. 28
	WCLH-FM 90.7	WYLN Ch. 35
	WBHT-FM 97.7	

Protective Actions

If releases of radiation from the plant were at levels high enough to affect public health and safety, the governor of Pennsylvania would order people who live near the plant to take protective action. In Pennsylvania, only the governor has the authority to order protective actions depending on actual or expected plant conditions. The two forms of protective action are sheltering and evacuation.

Sheltering

- Stay indoors until official word is given through the Emergency Alert System that it is safe to go outside.
- Close all doors, windows and vents, and turn off fans and air conditioners that draw in air from outside.
- If coming in from outside, wash thoroughly, especially before eating.

Evacuation

- Leave the area and go to temporary shelter facilities outside the 10-mile Emergency Planning Zone around the plant.
- Generally applies to the 70,000 people living within 10 miles of the plant.
- Emergency Planning Zone residents receive information yearly that lists evacuation routes and temporary shelters for an evacuation.
- School children would be taken to host schools outside the 10-mile area where their families can pick them up. Plans are in place to evacuate hospital and nursing home patients and others with special transportation needs.
- Special information is available to area farmers to help them care for animals during an emergency. Farmers living within 10 miles of the plant have been advised to keep a supply of covered feed for use if needed.

Emergency Classifications

The Nuclear Regulatory Commission has established four categories for nuclear power plant emergencies. The on-duty plant supervisor has 15 minutes to classify the event into one of these four categories:

Unusual Event

- A minor problem has occurred at the plant.
- No action by the general public is required.
- PPL notifies public officials, emergency management, news media and elected officials.

Alert

- A problem has occurred that may affect plant safety and has the potential to become more serious.
- No action by the general public is required.
- PPL notifies public officials and emergency management agencies, news media and elected officials. Emergency management agencies activate their emergency centers and coordinate support services.

Site Area Emergency

- A serious problem has occurred that has affected or may affect major plant safety systems.
- Radiation levels are not expected to be above federal limits at the site boundary.
- PPL notifies public officials and emergency management agencies, news media and elected officials.
- Local, county and state emergency centers are fully operational.
- Per PPL policy, employees who do not have necessary emergency or operation functions are asked to leave the plant because it is easier to manage an emergency with a smaller group of people whose only responsibility is returning the plant to normal operations.

General Emergency

- A problem has occurred or is imminent involving serious damage at the plant and failure of plant safety systems.
- Radiation releases are expected to exceed federal limits beyond plant property.
- Plant conditions may threaten public health and safety. If the governor of Pennsylvania decides protective action is necessary, county officials will sound sirens as a signal for people to turn on a radio or television and tune to an Emergency Alert System station for information and instructions.
- PPL notifies public officials and emergency management agencies, news media and elected officials.
- Local, county, state and federal emergency centers are fully operational and take any action needed to protect public health and safety.
- Per PPL policy, employees who do not have necessary emergency or operation functions are asked to leave the plant because it is easier to manage an emergency with a smaller group of people whose only responsibility is returning the plant to normal operations.

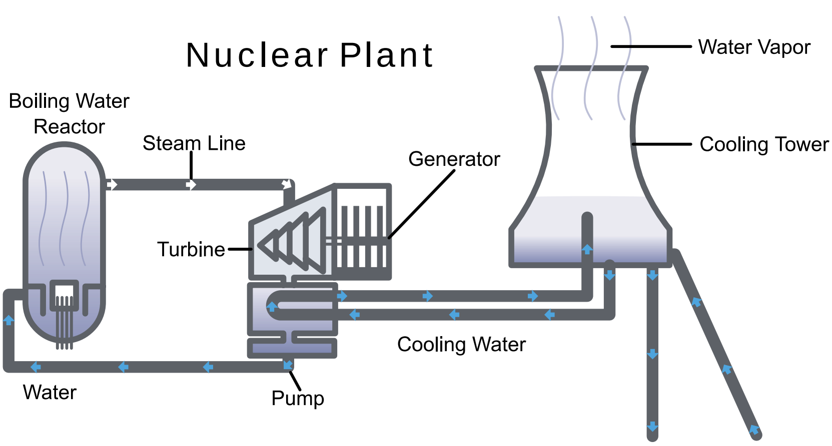
How Electricity Is Produced at SSES

Energy

- Susquehanna produces electricity by boiling water to create steam that turns a turbine-generator.
- Nuclear fuel does not burn like fossil fuels (coal, oil and natural gas) to produce electricity. Instead, heat produced by the energy released during nuclear fission, the process of splitting the nucleus of a uranium atom, causes water in the reactor to boil.
- At full power, each reactor makes about 14 million pounds of steam an hour.
- Steam passes through four turbines, each with hundreds of fan-like blades on rotating parts.
- Turbines turn a main generator at 1,800 revolutions per minute to produce electricity at 24,000 volts.
- Each unit has main transformers to increase the voltage to 230,000 volts on Unit 1 and to 500,000 volts on Unit 2 for transmission to customers.

Cooling

- After steam gives up energy in the turbine-generator, it enters the condenser, an enclosed tank with more than 600 miles of stainless steel tubes.
- Nearly 450,000 gallons of cooling water flow through those tubes every minute.
- The tubes keep the steam, containing some radioactive gases, separate from the cooling water.
- The steam comes in contact with the tubes, cools and condenses back into water.
- This water is collected, purified by a series of filters that trap mineral



particles suspended in the water (the condensate demineralizer system), heated and pumped back into the reactor to begin the cycle again.

Water

- As steam condenses, the temperature of the water used for cooling increases by about 30° F.
- After passing through the condenser, this non-radioactive cooling water is pumped to the cooling towers, where it trickles down over a series of baffles.
- As the water falls, it is cooled by evaporation.
- At full power, each cooling tower evaporates about 10,000 gallons per minute.
- Heat and water vapor rise from the cooling towers.
- Cooled water collects at the tower base and is pumped back to the condenser.
- Water from the Susquehanna River makes up for cooling water lost to evaporation.
- At full power, the plant uses about 20,000 gallons per minute from the river, less than 1 percent of the river's flow annually.

Plant Facilities

Reactor Buildings

- Two reinforced concrete and steel buildings, each about 200 feet tall, house the plant's nuclear reactors, as well as most of the equipment associated with plant emergency safety systems.
- Within each building, and surrounding each reactor, is a specially designed containment structure 160 feet tall with thick, steel-lined, reinforced concrete walls.

Turbine Building

- Two turbine-generators produce the electricity and are located in a 125-foot-tall building adjacent to the reactor building.
- Each turbine-generator assembly is 208 feet long, weighs about 650 tons and is mounted on a reinforced concrete pedestal more than 50 feet tall.

Control Structure

- Between the reactor and turbine buildings, but separate from both, is the 134-foot-tall control structure.
- This building contains the control room for both units and plant computer equipment.
- It has its own ventilation system that allows operators to remain in the control room even in the unlikely event that other areas of the plant must be evacuated.

Cooling Towers

- The two cooling towers are each 540 feet tall.
- Cooling water used in the plant flows down over a series of baffles, losing heat by evaporation as it falls.
- Water collects at the bottom of each tower for reuse in the plant. Non-radioactive water vapor rises from the towers.
- Cooling towers are not unique to nuclear plants; they are used at generating plants to conserve water and to limit thermal pollution by warm-water discharges to the river.
- PPL's Montour coal-fired power plant and the Martins Creek gas/oil-fired plant both use cooling towers.

Auxiliary Buildings

- Services and administration — a four-story building that contains offices for plant management and other support employees.
- South Building — a three-story building that contains offices for plant management and other support employees.
- Gatehouses — the only two points of entry into the plant. All visitors, packages and vehicles must be checked by plant security at these access points. For additional security, the plant is surrounded by a

double chain-link fence with intrusion detection systems at the fence line.

- Diesel generator buildings — house the plant's five diesel generators, which are backup power sources if the plant loses normal power supply. Four generators are located in a building to the east of the reactor building. The fifth is located in a nearby, separate building.
- Radioactive waste building — a reinforced concrete structure where the plant's low-level radioactive waste is processed. Located to the north of the turbine building, this building houses equipment that cleans up water for reuse in the plant.
- Low-level radioactive waste storage building — on-site facility designed for safe storage of up to 240,000 cubic feet of low-level radioactive waste. The building could handle all of Susquehanna's low-level radioactive waste for at least 10 years if necessary.
- Dry spent fuel storage — a modular dry fuel storage area used to store the plant's oldest spent fuel on an interim basis until the federal Department of Energy is ready to remove it. The NRC allows spent fuel that is at least 5 years old to be stored in dry steel containers inside concrete modules. This modular system can be expande as needed.

The Reactor

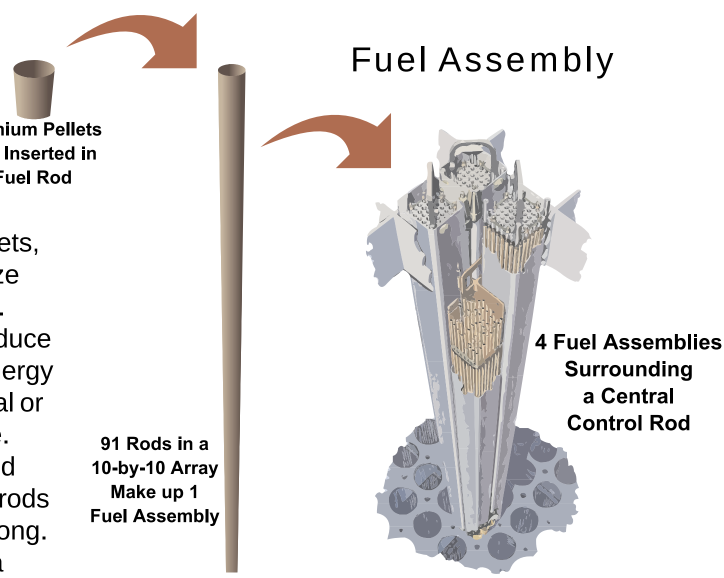
Vessels

- Each of Susquehanna's reactor vessels is a 750-ton cylinder about 21 feet in diameter standing more than 73 feet tall.
- The walls are made of carbon steel lined with stainless steel and are 4 to 9 inches thick.
- The reactor vessel contains about 130,000 gallons of water.
- The water serves three functions:
    1. It boils to become steam that drives the turbine-generator.
    2. It cools the reactor fuel to prevent overheating or melting.
    3. It moderates the reaction by slowing neutrons released in the fission process to make it more likely that those neutrons will split other atoms.
- Because of the importance of water to plant safety, Susquehanna has multiple backup safety systems, which can be operated manually or automatically, to keep the fuel covered with water.
- When the reactor is operating, water in the vessel is kept under pressure of about 1,000 pounds per square inch and at a temperature of 540°F.

Fuel

Susquehanna Plant Statistics

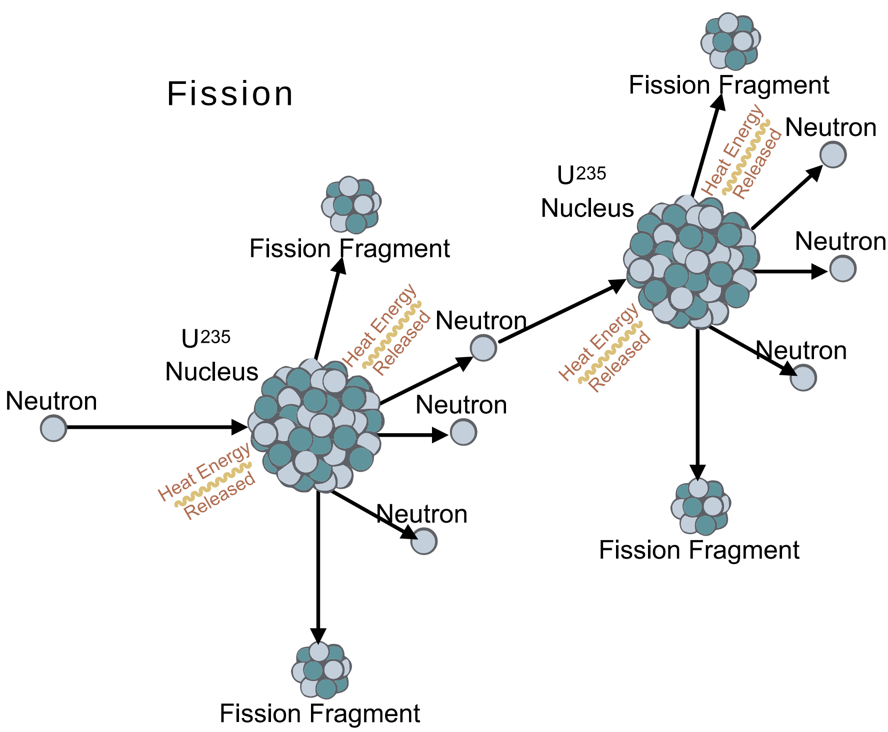
- Powering each reactor is about 132 metric tons of enriched uranium dioxide in the form of ceramic pellets.
- Each reactor is fueled by about 32 million of these pellets, which are about the size of an adult's thumbnail.
- A single pellet can produce the same amount of energy as 1,000 pounds of coal or 100 gallons of gasoline.
- Fuel pellets are stacked 12-1/2 feet high inside rods that are about 14 feet long.
- The rods are made of a special zirconium metal alloy and are arranged in bundles or assemblies. This metal tubing surrounding the fuel is also called cladding.



- Each assembly is made up of 91 rods, which are placed in a ten-by-ten array with a water channel in the center equal to a three-by-three array.
- The reactor core contains 764 of these fuel assemblies.

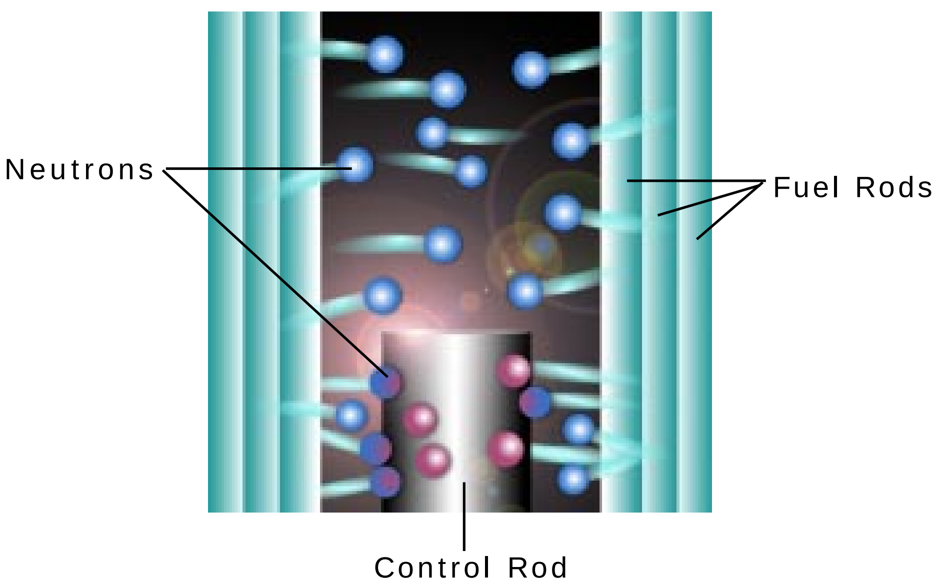
General Information

- The energy results from fission, the splitting of atoms into smaller parts. When atoms split, they give off energy in the form of heat.
- Uranium in nature consists primarily in two forms: U^{238}, which is the form of most uranium, and U^{235}.
- U^{235} readily reacts with neutrons — particles from the nucleus of an atom that have no electrical charge — and splits into two new atoms.
- As the uranium splits, it gives off other neutrons, which strike other U^{235} atoms, causing them to split. The continuous splitting of U^{235} atoms is called a chain reaction.
- The concentration of U^{235} in naturally occurring uranium is very low — less than 1 percent. For that reason, “light-water reactors” such as Susquehanna do not use raw uranium. Power plant fuel is enriched to increase its content of fissionable atoms to about 5 percent.
- Nuclear weapons fuel, by contrast, is enriched to contain more than 90 percent fissionable material.
- Low enrichment and reactor design make it impossible for nuclear power plant fuel to explode like a bomb.



Control Rods

- Plant operators control the nuclear reaction by the use of rods that insert between the fuel assemblies in the reactor.
- These control rods are made of stainless steel and filled with boron carbide, a substance that absorbs neutrons and prevents them from splitting other uranium atoms.
- Control rods are the same length as fuel rods.
- Each Susquehanna reactor has 185 control rods that insert from the bottom of the reactor.
- By withdrawing or inserting control rods, plant operators can speed up or slow down the nuclear reaction. As control rods are withdrawn from the reactor, the number of atoms splitting increases and the reaction speeds up. As control rods are inserted, the number of atoms splitting decreases and the reaction slows down.
- Operators can shut down the plant in seconds by fully inserting all the control rods at once.
- Under some conditions, control rods will insert automatically to shut down the plant. This type of rapid shutdown is called a “scram”.



Water Circulation

Water circulation is important to the operation of the Susquehanna units. Water is recycled continuously through the system: it boils to steam in the reactor, then is changed back to water in the condenser to be pumped back into the reactor.

Recirculation of water within the reactor increases the efficiency of the steam-making process and allows plant operators to get the maximum amount of power from each generating unit.

Key components of the water circulation system include:

Feedwater System

- Three large pumps, each capable of moving 17,000 gallons a minute, supply water to the reactor federal vessel.
- Before the water enters the reactor, a series of heaters brings it to the proper temperature.
- All three feedwater pumps must be operating for a unit to run at full power; a unit can continue to operate with one or two feedwater pumps, but at reduced power levels.

Recirculation System

- Two pumps provide continuous recirculation of water within each reactor.
- Recirculation increases the flow of water through the reactor core, allowing the reactor to produce more steam; more steam means the generating unit can produce more electricity.
- This system draws water out of the reactor and forces it to flow back through the core.
- Each recirculation pump moves about 45,000 gallons of water per minute.

Reactor Core Isolation Cooling (RCIC)

- This system provides make-up water to the reactor vessel when it is shut down, but still pressurized.
- It can be started manually from the control room or automatically if water in the reactor vessel drops below a certain level.

Spent Fuel

Eventually, nuclear fuel loses enough of its energy that it must be replaced. The Susquehanna plant schedules refueling outages for each unit every 24 months. During those outages, typically scheduled in the spring when demand for electricity is lowest, about one-third of the fuel is replaced.

- Fuel assemblies spend about four to six years in the reactor.
- Used fuel pellets in the assemblies being removed from the reactor contain radioactive waste byproducts of the fission process.
- The pellets are highly radioactive and will remain so for thousands of years.
- Susquehanna has facilities to store the used fuel safely until the government develops a disposal facility. The Department of Energy is responsible for disposal of nuclear power plant fuel.
- Water in the storage pools serves two purposes:
    1. It cools spent fuel that has recently been removed from the reactor and still produces heat.
    2. It provides an effective barrier that shields people from radiation.
- Over time, the amount of heat given off by spent fuel decreases.
- After five years, water is no longer needed for heat removal but continues to serve as an effective radiation barrier.
- Susquehanna's spent fuel pools have cooling and cleanup systems to keep water temperature below 125°F and to filter impurities from the water.

Dry Spent Fuel Storage

Susquehanna's modular dry fuel storage area is where the plant stores its oldest spent fuel on an interim basis until the federal Department of Energy is ready to remove it. The Nuclear Regulatory Commission allows spent fuel that is at least five years old to be stored in dry containers inside concrete modules. This modular system can be expanded as needed.

Defense in Depth

The design of Susquehanna, and all nuclear plants in the United States, is based on a "defense-in-depth" concept, which refers to the multiple layers of protection for public health and safety.

At the center are design features to contain radiation within the plant. The design includes redundant safety systems and imposing concrete and steel barriers. Beyond physical barriers are carefully developed work procedures and extensively trained personnel to ensure consistency and safety.

Design Safety Features

- The reactor is self-regulating; the nuclear reaction slows as the water surrounding it gets hotter.
- Fuel is formed into ceramic pellets that hold in most radioactive byproducts of nuclear fission. The pellets are then placed inside fuel rods made of a special metal alloy.
- Water in the reactor removes heat and captures radioactive byproducts that may escape the fuel.
- The plant has multiple levels of safety systems, all of which can operate manually or automatically.
- The reactor vessel has steel walls 4 to 9 inches thick.
- Surrounding the reactor is a containment structure with thick, steel-reinforced concrete walls. The containment structure sits inside the reactor building, which has steel-reinforced concrete walls.
- Reactor building air pressure is kept slightly lower than outside air pressure to protect against radioactive gases escaping the building.

Programs and Procedures

- A detailed emergency plan is in place to protect the public in the unlikely event of a serious accident. The plan has the support of local, county, state and federal governments, and is tested several times a year.
- Detailed work procedures are in place for every job to ensure consistency in how things are done and to provide a proven set of safe work guidelines.
- Procedures are reviewed regularly and revised as needed.
- Work procedures are designed with safety as the first priority.

Personnel

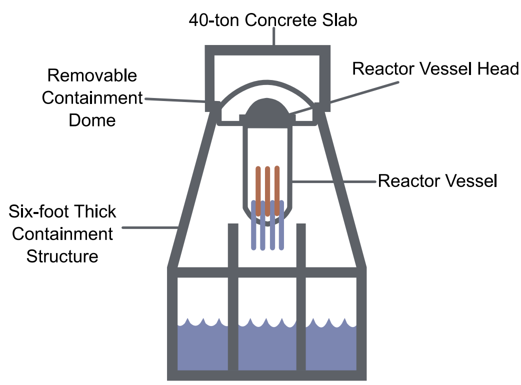
- Susquehanna has training programs in 11 separate disciplines for plant employees.
- Training programs are fully accredited by the National Academy for Nuclear Training.
- Every control room employee trains one week in six either in the classroom or on an advanced simulator.

- Licensed plant operators requalify for their licenses yearly.
- Many maintenance and technical support employees receive certification in their areas of expertise.

Containment

- Containment structures surround each Susquehanna reactor to keep radiation inside the plant and prevent or limit its release.
- The primary containment structure, located inside the reactor building, is made of 6-feet-thick concrete with a one-quarter-inch thick steel lining.
- The walls have 120 miles of 2-inch-thick steel reinforcing rods.
- The 160-foot-tall structure is designed to minimize the release of radioactive material in the unlikely event of a natural disaster or a reactor accident.
- Where pipes, electrical conduits and air lines pass through the containment structure walls, leak-tight seals keep radioactive material from escaping.
- Pipes that pass through the containment structure walls typically have valves both inside and outside containment for added safety.
- The reactor building serves as a secondary containment structure.
- To prevent air leakage that could allow radioactivity to escape in an accident, air pressure inside the reactor building is kept slightly lower than outside air pressure.
- The reactor building also has systems that filter out radioactive materials before they are released to the air.

Cutaway of Susquehanna Unit 1 Containment Structure



Cooling Water Sources

When atoms split in a nuclear power reactor, they produce heat. Even when the reactor is shut down, the fuel continues to give off heat. Without water, the core would become hot enough to melt the fuel pellets.

Susquehanna has multiple safety systems to ensure that an adequate supply of water covers the fuel at all times. Water for these safety systems comes from a variety of sources:

Condensate Storage

- Two tanks, each with a capacity of 300,000 gallons, hold a reserve supply of reactor water for makeup needs during normal operation, refueling or emergencies.
- In each tank, 135,000 gallons is reserved specifically for emergency core cooling systems. These systems can use all of the water in the tanks if necessary.

Suppression Pool

- Located in the containment structure below the reactor, this pool is 23 feet deep and contains nearly 1 million gallons of water.
- It is a main water supply source for the plant's emergency core cooling systems.

Spray Pond

- This 8-acre, man-made pond located on plant property contains 25 million gallons of water for cooling during normal plant operations and emergencies.
- Water level in the pond is maintained by adding water from the Susquehanna River as needed.

Emergency Core Cooling Systems

Susquehanna has a series of independent emergency core cooling systems to maintain water level in the reactor if normal plant cooling systems fail. The systems come on automatically if they sense a reactor water leak. Plant operators also may start them manually.

Some of the systems work when the reactor is at normal operating pressure. Other systems work when the pressure has been lowered.

High Pressure Coolant Injection (HPCI)

- Can add about 5,000 gallons of water per minute.
- Gets the emergency water to the reactor through pipes that feed water to the reactor during normal operation.

Automatic Depressurization System (ADS)

- Uses six safety relief valves on the plant's main steam supply system to reduce pressure quickly inside the reactor.
- Allows low-pressure cooling systems to operate and flood the reactor.

Core Spray (CS)

- Low-pressure system that sprays water directly onto the fuel through nozzles located above the fuel.
- Core spray has two independent systems; each can spray about 6,000 gallons of water a minute.

Low Pressure Coolant Injection (LPCI)

- High-flow system that can pump 42,600 gallons of water a minute into the reactor using pipes that serve the recirculation system during normal operation.

Air Filtration System

Standby gas treatment is an air filtration system used to minimize the effect of airborne radiation releases during an emergency at the Susquehanna plant. The system has several functions:

- Helps keep air pressure inside the reactor building slightly lower than outside air pressure to prevent an uncontrolled, unfiltered release of radioactive material.
- Filters 99.9 percent of the radioactive iodine through a series of activated charcoal beds.
- Filters 99.9 percent of the radioactive particulate matter.
- Forces chemically inert radioactive gases through a long ventilation route before leaving the plant, during which time these gases lose much of their radioactivity.

Emissions from the standby gas treatment system go through a vent on the reactor building roof. The vent is monitored continuously by sensitive radiation detection equipment.

Computers analyze monitor data and weather conditions to determine the size and direction of a release. That information helps public officials decide whether to order people to take protective action in the unlikely event of a nuclear emergency.

Power Supply Sources

Susquehanna has several independent power sources that supply electricity to plant systems.

Power Lines

- Plant safety systems get electricity from two independent power lines in PPL Utilities' power supply system, which serve as backups to each other.
- The two lines feed separate power transformers.
- Either can provide enough power to meet plant needs.

Diesel Generators

- If both power supply lines fail, the plant has five diesel generators as backups.
- The diesel generators come on automatically to provide power within 10 seconds of power supply loss.
- The plant must have four generators available to operate when either unit is in service.
- The fifth serves as a spare to replace any of the others.
- Susquehanna keeps enough diesel fuel at the plant to run the generators for 30 days.

Radiation

What Is It?

Radiation is energy in the form of particles or waves, such as light, heat, microwaves and radio waves. These “non-ionizing” forms of radiation do not have enough energy to change the structure of atoms. In nature, atoms of most elements are stable; they won’t change on their own.

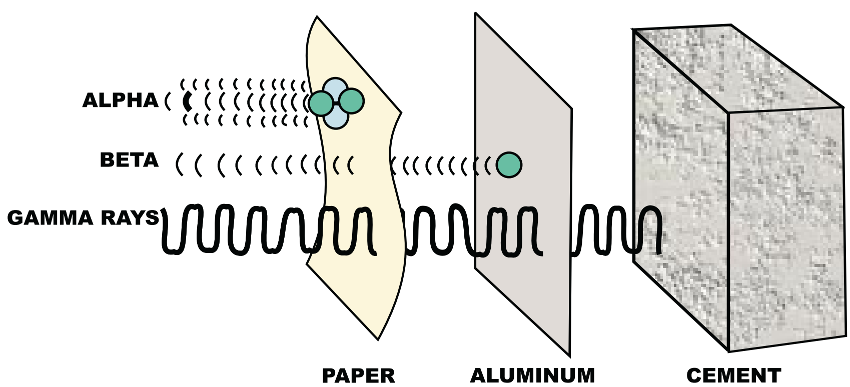
Natural and man-made ionizing radiation, however, has enough energy to change the structure of atoms. Radioactive atoms are unstable. To reach a stable state, they give off their excess energy through a natural process known as “decay”.

The main types of radiation emitted as byproducts of nuclear power generation are:

- Alpha particles — the heaviest and least penetrating form of radiation, they can be stopped by a sheet of paper.
- Beta particles — smaller and more penetrating, they can be stopped by a block of wood or thin sheet of metal.
- Gamma rays — the most penetrating form of radiation, it takes a dense material such as lead or several feet of concrete to stop these highly energetic waves.

Ionizing radiation may damage the cells of living things by changing the structure of their molecules. Exposure to very large amounts of radiation in a short period of time can cause immediate health problems.

Barriers to Radiation



Source: A Basic Guide to Nuclear Power, Edison Electric Institute

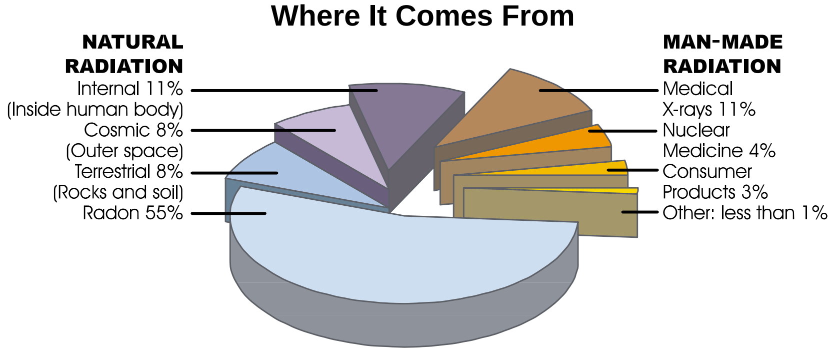
Exposure

Radiation is a natural part of the environment. It is in the air we breathe, the water we drink and the food we eat. The human body is naturally radioactive.

Biological effects of radiation are measured in units called millirem. The government sets radiological protection standards based on millirem received over a specified period of time.

- People living in the United States are exposed to an average of about 360 millirem a year. Natural sources account for about 82 percent of the total annual exposure.
- About 200 millirem of exposure is due to naturally occurring radon gas in the air that seeps up from the ground.
- Other natural sources of radiation exposure are the human body, rocks and soil, and cosmic radiation from outer space.
- Man-made radiation sources account for about 18 percent of a person's total annual exposure (about 55 millirem) and come from diagnostic X-rays and other medical procedures.
- During normal operations, the Susquehanna plant releases minute quantities of radiation to the air through filtered ventilation systems and occasionally into the Susquehanna River. These releases are carefully controlled and are monitored continuously to stay well below the strict federal limits.
- Extensive field monitoring has shown essentially no effect on the environment from normal Susquehanna operations.
- The maximum amount of radiation a plant area resident receives is less than one-tenth of 1 millirem a year; most people are exposed to lesser amounts. One-tenth of 1 millirem is 100 times less than the 10 millirem a person would receive from a single dental X-ray.
- Federal regulations limit the exposure for nuclear power plant workers to 5,000 millirem a year.
- Because of strict radiation controls and work procedures at Susquehanna, the average annual exposure for plant workers is about 330 millirem a year.
- The onset of symptoms associated with radiation sickness begins

Radiation Exposure
Where It Comes From



Source: Radiation in Perspective, Nuclear Energy Institute

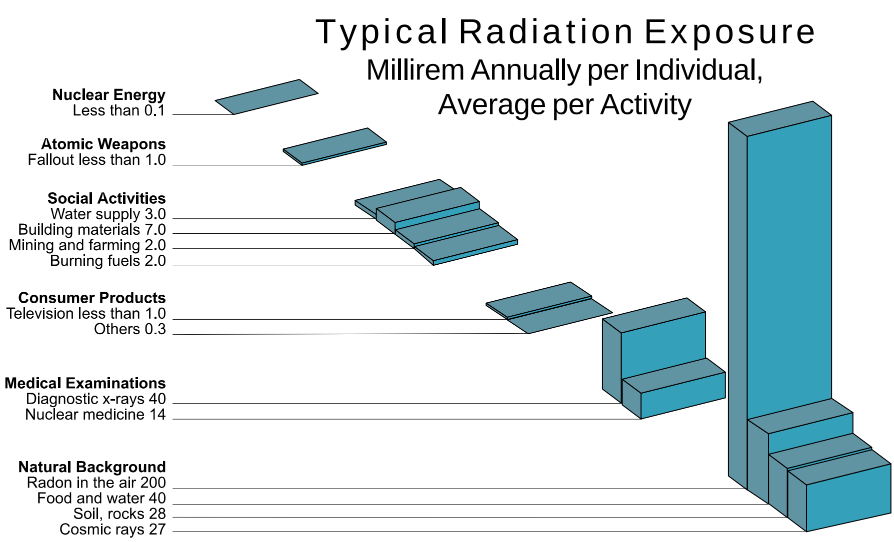
at a single dose of about 100,000 millirem.
- A single dose of 400,000 millirem or more would be fatal within 30 days to 50 percent of the people exposed.

Contamination

- Contamination occurs when radioactive material is deposited on non-radioactive surfaces. Inside a nuclear power plant, tools, filters and other plant components routinely become contaminated through contact with radioactive materials.
- Plant workers wear special protective clothing and equipment to protect against contamination.
- Access controls are in place at the plant where there are radiological hazards.
- Despite these measures, radioactive material can get on plant workers' clothing or skin.
- Monitors located throughout the plant detect radioactive contamination; employees pass through them when entering or leaving various work areas and when leaving the plant.
- Radioactive contamination usually is removed from clothing or skin by washing with soap and water at the plant.
- If an injured plant worker is contaminated and needs immediate medical treatment, nearby Berwick Hospital has facilities to prevent the incidental spread of radioactive material while hospital staff treat the injured worker.

Measuring and Detecting Radiation

- Radiation is measured via the number of atoms decaying per second.
- It is possible to detect a single atom decaying.
- The unit of measure for radiation is the Curie. One Curie is equivalent



Source: Radiation in Perspective, Nuclear Energy Institute to 37 billion atoms decaying per second (the amount of radiation in one gram of radium).

- Susquehanna has a series of monitors inside and outside to detect and measure any radiation released. The state and federal governments also maintain radiation monitors in areas around the plant.
- PPL conducts extensive environmental monitoring around the plant, collecting about 2,000 samples a year at 140 locations.
- Outside laboratories analyze these samples (air, water, vegetation, soil, animal and milk) for radiation.
- The Philadelphia Academy of Natural Sciences conducts independent monitoring.
- In the event of a plant emergency, mobile teams of trained people would measure and track radiation releases and identify contaminated areas inside and outside the plant.
- The information they provide would supplement stationary monitors and help determine whether the public needs to take protective action, such as sheltering or evacuation.

Glossary

alert

Second lowest of four emergency classification levels established by the Nuclear Regulatory Commission. It means a problem has occurred that may affect plant safety and has the potential to become more serious. No public action is necessary.

alpha particles

The heaviest and least penetrating form of ionizing radiation. They can be stopped by clothing or a sheet of paper.

atom

The basic building block of elements. Atoms consist of a nucleus, orbited by particles with a negative electrical charge (electrons). Within the nucleus are particles that have a positive electrical charge (protons) and particles that have no electrical charge (neutrons).

background radiation

Radiation that occurs naturally in the environment, such as radon gas from the ground, cosmic rays from space and radioactive elements in the human body.

beta particles

Small, high-energy particles of ionizing radiation. They have enough energy to penetrate skin deeply enough to damage tissue, but can be stopped by a block of wood or thin sheet of metal.

cladding

Metal tubing, made from a special alloy, which surrounds uranium fuel pellets.

condensate demineralizer

A large filter vessel used to remove impurities from water before it is returned to the reactor. Each unit at Susquehanna has seven available.

condensate storage tank

A 300,000-gallon tank that holds a reserve supply of reactor water for use during normal operations, refueling or emergencies. There is one tank for each unit at Susquehanna.

condenser

A plant system that draws steam from the turbine and, by forcing it to pass over a series of tubes filled with water, cools the steam to water for reuse in the reactor.

containment
Physical barriers to prevent or limit the release of radiation in the event of a serious accident. Primary containment is a massive steel-reinforced concrete structure. Secondary containment has steel-reinforced concrete walls and air pressure lower than outside air pressure to prevent air leaks.

contamination
Radioactive material deposited on a non-radioactive surface.

control rod
A stainless steel rod filled with a material (boron carbide) that absorbs neutrons. These rods are inserted between the fuel bundles to control or stop the nuclear reaction.

core
The area inside the reactor vessel where the fuel is located and where the fission process takes place. Also refers to the fuel itself.

critical
Term used to describe a reactor sustaining a nuclear reaction.

curie
Unit used to measure the amount of radioactivity in a substance.

decay
The process by which an atom gives off energy, in the form of radioactive particles or waves, in order to reach a stable state.

defense in depth
Concept used in the design of nuclear power plants to improve safety. It uses multiple protective barriers and multiple backup systems to prevent or limit the release of radiation.

emergency alert system
Radio and television stations used by county emergency management officials to broadcast official information and instructions during an emergency.

emergency planning zone
The geographic area within 10 miles of the Susquehanna plant that includes 27 municipalities in parts of Luzerne and Columbia counties. About 70,000 people live in this area.

enrichment
The process by which the concentration of fissionable atoms in raw uranium is increased from less than 1 percent to about 4 percent so it can be used as power plant fuel.

fission

The splitting of atoms into smaller parts, which results in a release of energy.

fuel assembly

An arrangement of rods containing uranium fuel. Susquehanna fuel assemblies have 91 rods in a 10-by-10 array, with a central water channel equal to a 3-by-3 array. Each reactor contains 764 fuel assemblies.

fuel bundle

See "fuel assembly."

fuel rod

A 14-foot-long tube, made of a special metal alloy, that is used to hold uranium fuel pellets.

gamma rays

Waves of ionizing radiation energetic enough to pass through the body. It takes dense material, such as lead or several feet of concrete, to stop gamma rays.

general emergency

The highest of four emergency classification levels established by the Nuclear Regulatory Commission. It means a problem has occurred involving serious damage to the plant, failure of plant safety systems and/or the release of radiation beyond plant property.

half life

The time it takes for a radioactive substance to lose half of its radioactivity through decay. Each radioactive substance has a unique half life.

low-level radioactive waste

Material that becomes contaminated through use and contact with radioactive materials. At Susquehanna this includes filter materials, protective clothing, tools, rags and other solid wastes.

millirem

The unit used to measure biological effects of radiation.

neutrons

Particles within the nucleus of an atom that have no electrical charge. In a nuclear power reactor, they sustain the reaction by splitting fissionable uranium atoms.

radiation

Electromagnetic energy in the form of particles or waves. In a nuclear power plant, the particles or waves are emitted by unstable atoms undergoing decay.

reactor

The large metal vessel where atoms are split to create the heat needed to boil water and produce steam that turns a turbine to generate electricity.

risk counties

Counties that have residents who live within 10 miles of the power plant and who may be asked to take protective action in the event of an emergency at the plant. The risk counties for Susquehanna are Luzerne and Columbia.

scram

The rapid shutdown of a nuclear power reactor by the insertion of all control rods into the core to stop fission. Control rods can insert automatically or at the direction of plant operators.

site area emergency

The second highest of four emergency classification levels established by the Nuclear Regulatory Commission. It means a problem has occurred involving actual or likely failure of plant safety systems.

spent fuel

Fuel that can no longer produce enough energy to support full-power operation of the plant. It is highly radioactive and requires special handling for safety.

spray pond

An 8-acre, 25-million-gallon, man-made pond on Susquehanna plant property that serves as a source of cooling water for normal plant operations and emergencies. It holds enough water to meet all plant cooling needs for a minimum of 30 days.

suppression pool

A source of nearly 1 million gallons of water for emergency cooling systems in the Susquehanna plant. There is a pool located beneath each reactor.

transformer

A device used to increase or decrease the voltage of electricity.

unusual event

The lowest of four emergency classification levels established by the Nuclear Regulatory Commission. It means a minor problem has occurred at the plant and no public action is necessary.

uranium

The element used to fuel a nuclear power reactor. Uranium in nature consists mainly of two isotopes, U^{235} and U^{238}. The U^{235} atom readily reacts with neutrons and splits into new atoms.

Other Sources of Information

U.S. Nuclear Regulatory Commission
Office of Public Affairs
Washington, D.C. 20555
(301) 415-8200

U.S. Nuclear Regulatory Commission
Region I Office
475 Allendale Road
King of Prussia, PA 19406
(610) 337-5000

Federal Emergency Management Agency
Region III Office
105 S. 7th St.
Philadelphia, PA 19106
(215) 931-5500

Pennsylvania Emergency Management Agency
2605 Interstate Drive
Harrisburg, PA 17110-9364
(717) 651-2001

Pennsylvania Department of Environmental Protection
Bureau of Radiation Protection
P.O. Box 2063
Harrisburg, PA 17105-2063
(717) 783-2300

Luzerne County Emergency Management Agency
200 N. River St.
Wilkes-Barre, PA 18711-1001
(570) 820-4400

Columbia County Department of Public Safety
P.O. Box 380
Bloomsburg, PA 17815
(570) 784-6300