Fort Calhoun Station

About the Plant

Fort Calhoun Station is a 482,000-kilowatt nuclear power plant owned and operated by Omaha Public Power District. It is located on the Missouri River 19 miles north of Omaha.

Designed and constructed at an initial cost of $178 million, the plant began the commercial production of electricity on Sept. 23, 1973. Since that time, it has accounted for approximately 32.4 percent of OPPD's total generation.

The 1966 decision to go nuclear was based on studies showing that a nuclear plant would be a safe, reliable and environmentally clean means of producing electricity. Experience to date supports those early findings.

The plant was designed with a series of redundant safety systems, which greatly reduce the chance of an accident. In addition, the plant's design includes a "defense in depth" system of barriers to prevent the escape of radioactivity to the environment in the unlikely event of an accident.

Safety remains the number one priority in operating the plant today. In 1993, the Nuclear Regulatory Commission (NRC) granted a five-year extension to the operating license for Fort Calhoun Station, which allowed the plant to operate until 2013. In 2003, the NRC renewed the plant's operating license an additional 20 years – until 2033. Before granting the extensions, the NRC had to determine beyond any doubt that the plant was in good physical condition and would be able to run safely throughout the extended time periods.

In 2006, Fort Calhoun Station underwent a refurbishment outage that reached a scope no power plant in the U.S. had ever attempted. The project included replacing the steam generators, reactor vessel head, pressurizer, low-pressure turbines and main transformer. Other plants had replaced these same components, but Fort Calhoun Station was the first pressurized-water-reactor plant in the world to replace all of them during the same outage. OPPD brought the plant back online on schedule and about $32 million under the $417 million budget. Because of the scope of this work, extraordinary planning, preparation and training measures were taken to ensure swift execution of the projects.

Important Features

Containment Building – Constructed of steel-reinforced concrete, with walls almost four feet thick. A one-fourth-inch-thick carbon steel liner on the inside of the Containment Building ensures leak-tightness. Capable of withstanding an internal pressure greater than the maximum pressure that could be created in the unlikely event of a rupture of the largest primary pipe in the reactor coolant system. Designed to maintain integrity against the impact of objects propelled by tornadic winds. For example, a 4,000-pound car driven by a 500-mph wind would not penetrate the Containment Building.

Auxiliary Building – Houses the reactor auxiliaries, including waste-treatment facilities, certain safety components, the control room, emergency diesel generators, and fuel-handling and storage facilities. The Auxiliary Building is a heavily reinforced concrete structure that forms a "U" around the Containment Building and is seismically designed to withstand tornadoes and earthquakes.

Turbine Building – Houses the turbine generator, condensers, condensate and feedwater pumps, feedwater heaters and other turbine heat cycle components. A structural steel superstructure enclosed with resin wall paneling, it has a reinforced concrete basement.

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Important Features
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Service Building – Office space attached to, and of the same construction as, the Turbine Building.

Intake Structure – Houses the equipment that pumps cool river water into the plant for use in condensing steam leaving the turbine. The building, which is seismically designed, consists of a structural steel frame enclosed by resin wall panels similar to the Turbine Building. The intake structure is made of heavily reinforced concrete below the 1,014-foot elevation and extends over the Missouri River.

Security Building – Serves as the main entrance to the plant and ensures that only authorized personnel, free of any unauthorized contraband, are allowed access.

Switchyard – Houses equipment that is connected to the main generator at Fort Calhoun Station. This equipment feeds electrical power to OPPD's service area.

Administration Building – Houses administrative offices for senior nuclear managers, nuclear engineering groups and security personnel. Contains offices and conference rooms for Nuclear Regulatory Commission personnel who visit the plant regularly to evaluate plant operations and performance. A fitness-for-duty laboratory, radiological health area and cafeteria make up some of the other work areas. Completed in 1991.

Training Center – All nuclear-related training is conducted in this facility, which includes a 100-seat auditorium and various laboratories, including ones dedicated to pressure equipment, chemistry, radiation protection, instrumentation and control, and general maintenance. It contains a control room simulator, which is a precise replica of the station's main control room. Completed in 1989.

Radioactive Waste Processing Building – OPPD personnel use facilities in this building to sort, compact, decontaminate and store (short-term) low-level solid and liquid radioactive waste. In this building, contaminated waters, valves, metals and other hard objects can be cleansed of radioactive contaminants. The Radioactive Waste Processing Building has a rigid steel framework to support the precast concrete panels of its exterior. It is seismically designed for adequate strength and rigidity so it won't adversely affect the adjacent Auxiliary Building in the event of an earthquake or tornado.

Chemistry and Radiation Protection (CARP) Building – Houses chemistry laboratories, a cafeteria, offices, lockers and showers. The labs are used for both radiological and non-radiological functions required for plant operation.

Warehouse – All shipments to the plant are processed through this building. Material, spare parts and equipment are received, inspected, stored and issued from the 40,000-square-foot facility.

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Using the Atom to Produce Electricity

A nuclear power plant, such as Fort Calhoun Station, operates essentially the same way as a fossil-fuel plant. The basic difference is the source of the heat that is used to produce steam.

- The process that produces the heat in a nuclear plant is the fissioning or splitting of uranium atoms.
- The part of the plant where the heat is produced is called the reactor core, and the fuel used in the reactor at Fort Calhoun Station is uranium dioxide.

Like all matter, uranium is composed of extremely small particles called atoms. The uranium atom splits, or fissions, when struck by an even smaller particle called a neutron. The fragments from the split atom fly apart at great speed and generate heat as they collide with other atoms.

As each atom is split, it not only gives off heat, but it also releases two or three additional neutrons. These neutrons may in turn strike other uranium atoms, causing more fission reaction. In the Fort Calhoun Station reactor, many trillions of fissions take place every second, producing a great amount of heat.

This heat is used to boil water and produce steam. From that point on, the process of generating electricity is the same as in any fossil-fuel plant.

- The steam, under high pressure, passes through the blades of a turbine, making the turbine spin at high speed. A generator is attached to the turbine, and the rotating shaft of this generator has a magnetic field and is also surrounded by coils of wire.
- When the turbine spins the generator's shaft, a magnetic field in the wire coils produces electricity.

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Inside the Nuclear Reactor - What's There?

At the heart of any nuclear generating station is the reactor. The reactor contains a sufficient quantity of nuclear fuel to achieve the fission chain reaction. The nuclear reactor starts, stops and controls the fission process.

- To control the rate of fission, the quantity of free-moving neutrons is regulated within the reactor. This is done at Fort Calhoun Station by a series of control rods made of boron carbide. Boron absorbs neutrons much like an ink blotter soaks up ink.
- When the rods are inserted into the reactor vessel, they absorb neutrons and slow the fission process. By fully inserting the control rods, the fission process stops and the reactor is immediately shut down. When the control rods are withdrawn, the rate of fission increases.
- In OPPD's reactor, an additional means of control is provided by adding boron in the form of boric acid solution to the reactor's coolant water. Increasing or decreasing the concentration of boric acid has the same effect on the reactor as inserting or withdrawing control rods.

The reactor is composed of the following elements:

Fuel – The nuclear fuel is the heart of the reactor. In most U.S. reactors, the fuel consists of pellets or ceramic uranium dioxide. At Fort Calhoun Station, these pellets are 0.476 inches long and 0.3805 inches in diameter. These pellets are sealed in thousands of zirconium alloy tubes, about 11 and 1/3 feet long, called "fuel pins." Fuel pins are assembled into bundles, 176 to a bundle. These bundles are called fuel assemblies. There are 133 fuel assemblies in the reactor at Fort Calhoun Station.

Control Rods – These rods have five fingers containing materials that, when inserted into a fuel assembly, absorb neutrons. In normal operation, the control rods are positioned and held directly above the fuel assemblies in the reactor core. If power to the control rod drive mechanism is shut off, or if it's lost for any reason, gravity takes over and the rods drop into the fuel assemblies, stopping the fission process and thus shutting down the reactor – all within 2.5 seconds.

Coolant – The reactor coolant at Fort Calhoun Station is water, pumped through the reactor under pressure. This pressurized water carries away the heat produced by the fissioning of the fuel. This water then passes through one of two steam generators where its heat is transferred to a secondary water system. The secondary system, which is at a lower pressure, is allowed to boil, producing steam.

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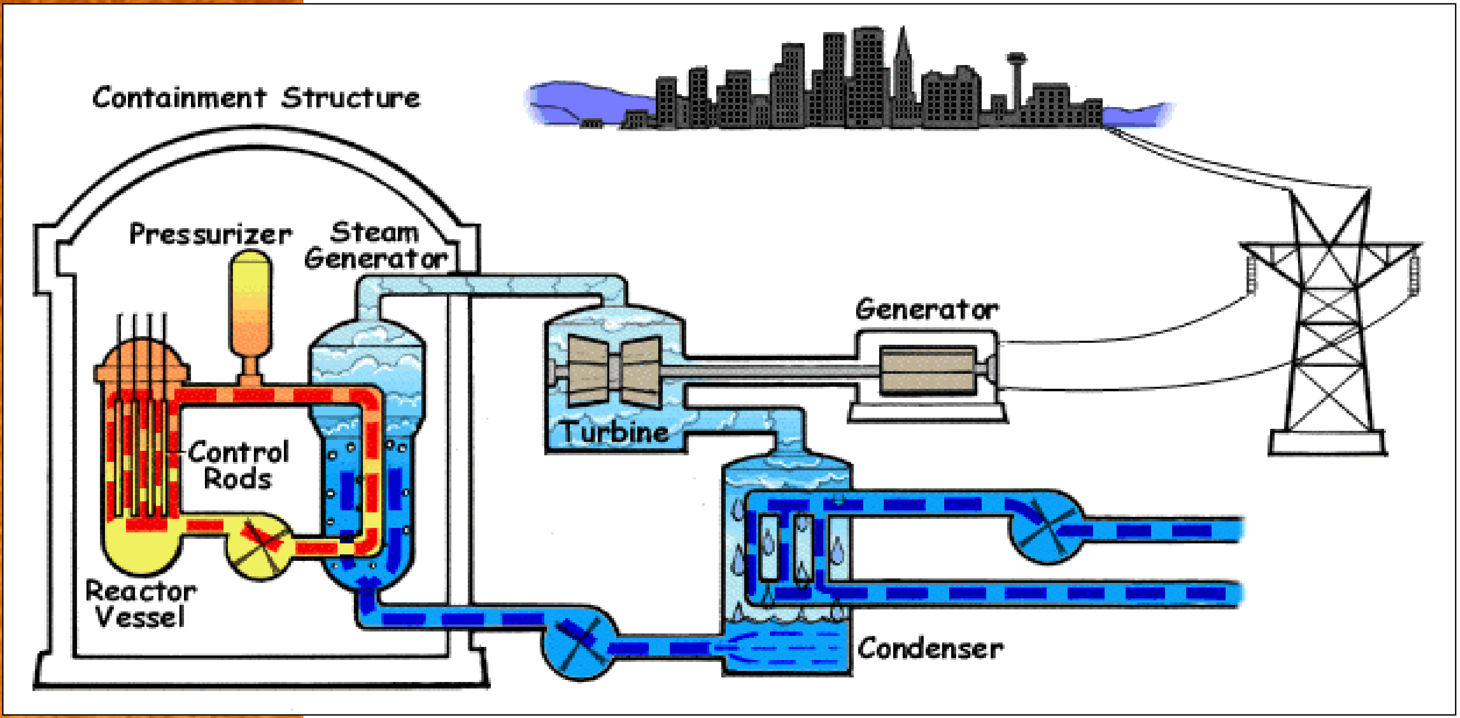
Inside the Nuclear Reactor - What's There?
(continued)

The nuclear steam-supply system at Fort Calhoun Station consists basically of a pressurized water reactor and two steam generators.

- The uranium fuel in the reactor produces heat through the fission process. Primary coolant circulates through the reactor core, picking up heat as it flows around the nuclear fuel. The primary coolant reaches a temperature of about 590 degrees Fahrenheit, but it does not boil because it is pressurized at 2,100 pounds per square inch. The pressurized water then flows through piping to the steam generators, where its heat is transferred to a secondary water system. (Water in the two systems is separated by metal tubing and does not mix. Only the heat is transferred.)
- The primary coolant, after giving up heat to the steam generators, is returned to the reactor to be heated again. Water in the secondary system is converted to steam, which is routed to a turbine. The steam rotates the turbine, which drives a generator, producing electricity.
- After the steam leaves the turbine, it is condensed into water by passing over tubes containing cool river water. It is then returned to the steam generators to be reheated into steam again.

The river water used to condense the steam is now slightly warmer. It is returned to the river where its heat is given up to the atmosphere.



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Radiation: It's not a Mystery

Much of the concern about nuclear plant safety may be attributed to lack of understanding, particularly about radiation and radioactivity.

There is nothing new or mysterious about radiation. It has always been part of our natural environment. We are constantly exposed to radiation from the sun and outer space. Naturally occurring radioactive materials are present in the earth around us, in the buildings we live and work in, and in the food and water we consume. There are radioactive gases in the air we breathe, and our bodies themselves are radioactive to some degree.

The levels of this natural radiation vary greatly from place to place. Persons living in Denver, for example, receive double the amount of natural radiation as we do in this part of Nebraska and Iowa. That's mostly because of Denver's higher altitude.

We are also exposed to sources of radiation of our own making. For more than half a century, doctors and scientists have used X-rays and other forms of penetrating radiation. Medical diagnosis and treatment are the main sources of public exposure to man-made radiation, and the benefits in terms of human lives saved far outweigh any potential problems.

A nuclear power plant is also a source of man-made radiation, although in normal operations, the amount reaching the environment is so small that it's barely detectable.

The natural radiation we receive each year from the sun and earth, from what we eat and drink, and from medical diagnosis and treatment is hundreds of times greater than that released to the environment by a nuclear power plant.

Within a decade after X-rays came into use, it became apparent that they could be either beneficial or harmful depending on their use and control, and that protective measures were necessary. This applies to other kinds of radiation as well, including that produced in the nuclear power industry.

The effect that radiation from any source has on us depends upon the nature and power of the rays and particles that strike us. It also depends upon the length of time we are exposed to them, how much of our body surface is struck by them, and how much radioactive material we breathe or ingest into our body.

Consequently, nuclear power plants are designed and built to contain radioactivity and prevent it from reaching the environment, both during normal operation and in the event of an accident. These contain-and-prevent efforts by the industry have worked.

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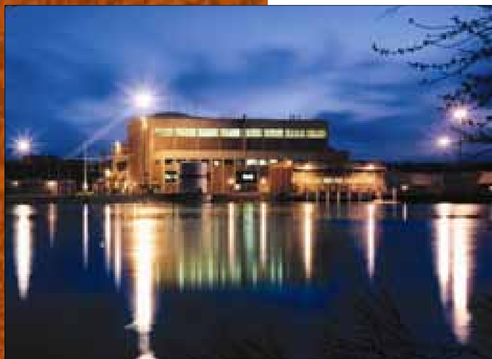

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The Nuclear Fuel Cycle

The first step in the nuclear fuel cycle is the mining of the uranium.

After the ore is mined, the uranium is extracted by a chemical process called milling. The refined uranium is then enriched – a process that increases the proportion of U-235, the most highly fissionable uranium isotope. Natural uranium contains 0.7 percent U-235. The uranium fuel used in OPPD's reactor is enriched to greater than four percent U-235, with the rest being primarily U-238, a non-fissionable isotope.

The enriched uranium, uranium dioxide (UO2), is fabricated into ceramic pellets 0.476 inches long and 0.3805 inches in diameter. The fuel in OPPD's reactor consists of more than six million pellets. Each of these pellets can produce approximately the same amount of electricity as 2,400 pounds of coal.

The pellets are stacked and sealed in tubes or rods, made of zirconium alloy. These fuel rods are about 11 and 1/3 feet long and about ½ inch in outside diameter. The fuel rods are then bundled together into fuel assemblies. There are 176 rods in each fuel assembly and 133 assemblies in the reactor core.

Spacer grids in each fuel assembly separate the fuel rods from one another. The reactor coolant or moderator water will circulate through these spaces between the fuel rods.

The nuclear fuel in OPPD's reactor is replaced on a regular basis. The lifetime of a batch, approximately one-third of the total amount of nuclear fuel, is four to five years. Every 18 months, the oldest batch of fuel (about 44 assemblies) is removed, and a fresh batch is placed into the reactor.

Used fuel is stored in the spent fuel pool – an area that resembles a swimming pool about 43 feet deep. The spent fuel pool is a reinforced concrete structure lined with stainless steel that provides storage capacity for 1,083 fuel assemblies.

The spent or used fuel taken from OPPD's reactor contains valuable material that can be reclaimed. In fact, only about three percent of the uranium is used, while the remainder is still locked in the fuel rods.

The Nuclear Waste Policy Act of 1982, as amended in 1987, provides for eventual shipment of this material to federal repositories. In the meantime, Fort Calhoun Station's spent fuel pool and on site dry-cask storage of the oldest spent fuel assemblies will be used to provide the necessary storage space.

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Managing Nuclear Waste

Nuclear generating plants produce a relatively small volume of waste compared to other types of electric-generating plants. This is one of the advantages of a nuclear plant – the volume of waste is small and easily managed. There are two types of nuclear waste: low-level and high-level.

Low-level waste includes exhausted resin, exhausted filter elements, retired equipment, clean-up liquids, protective garments discarded by workers, and other industrial rubbish that may contain very small amounts of radioactivity. The radiation levels in these materials are relatively low, and their decay is fairly rapid.

Much of the low-level waste is transported to a processing facility, where various methods, such as incineration and super-compaction, are used to reduce the volume of the waste as much as possible before it is placed into metal disposal containers. Other waste, such as filters and exhausted resin, is placed into high-integrity containers designed to ensure stability of the waste form. This low-level waste is eventually disposed of at federally licensed disposal facilities.

The used or spent fuel from nuclear reactors is the only source of high-level radioactive waste from nuclear generating plants.

At Fort Calhoun Station, spent fuel is stored under water in a special structure of steel and concrete, where the radioactive elements are allowed to decay. Eventually, this high-level waste will be shipped to a federally licensed repository. Starting in 2006, some of the spent fuel at the Fort Calhoun Station was transferred from the spent fuel pool to an on site dry-cask storage facility, because the spent fuel pool is reaching its storage limit of spent fuel assemblies and a federally licensed repository has not been built.

Nuclear generating plants are not the main source of our nation's high-level radioactive waste. More than 95 percent of such waste comes from the national defense program. An additional small amount comes from nuclear medicine, university research, and other commercial sources.

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Nuclear Energy and The Environment

Nuclear energy is the cleanest method available today to generate large amounts of electricity. It emits no smoke or other pollutants into the atmosphere.

Fort Calhoun Station's effect on the environment has been checked regularly since construction began on the plant. Environmental assessments continue through the lifetime of a nuclear generating plant.

OPPD environmentalists collect air particulate samples. These samples tell if any radiation has been released from the plant. Well water and surface water from the Missouri River are also sampled. Local vegetation, wildlife, farm animals, crops and soil are also monitored on a continuous basis.

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Safety

OPPD has been producing electricity at Fort Calhoun Station, safely and efficiently, since 1973. Safety has always had the highest priority in the design and construction of the plant, and it has remained the number one priority in daily operations ever since. Because of the abundance of safeguards in the design, construction and operation of Fort Calhoun Station, the chance of an accident affecting the public health and safety is extremely remote.

The safety approach used at Fort Calhoun Station follows the "defense-in-depth" concept employed by all commercial power plants in this country. The defense-in-depth concept includes multiple physical barriers to protect against the release of fission products and several engineered safety features to prevent or mitigate the damage that might occur due to an accident.

The approach also includes numerous procedural barriers to prevent or mitigate damage and extensive training for all personnel involved with the operation of the plant.

A series of engineered safeguards – back-up safety systems – ensures that the nuclear fuel in the reactor core remains covered with cooling water, even if there is a loss-of-coolant accident. These redundant water-injection systems prevent the fuel in the core from melting and accidentally releasing its radioactive content.

Beyond this, however, there are also physical barriers to prevent the release of large quantities of radioactivity from the reactor system to the environment during either normal operations or accident conditions.

These physical barriers include:

- The nuclear fuel itself, fabricated into dense ceramic pellets, inside which most fission products remain bound.
- The fuel pins of zirconium alloy, about 11 and 1/3 feet long and half an inch in diameter, into which the fuel pellets are stacked and sealed. The zirconium alloy used in the construction of the fuel pins is a highly corrosion-resistant metal alloy.
- The steel reactor pressure vessel is 39 feet high and 13 feet in diameter, with seven-inch-thick steel walls. It contains about 23,000 fuel pins assembled into 133 fuel assemblies that make up the reactor core.
- The reactor coolant system consists of high-strength steel piping, pumps, valves and other components attached to the reactor pressure vessel. The reactor pressure vessel and reactor coolant system provide the leak-tight environment for the cooling water for the system.
- The massive Containment Building is a steel-reinforced concrete structure, with walls and dome nearly four feet thick and steel-reinforced concrete floor more than 12 feet thick and securely anchored to solid bedrock. This heavy containment structure guards against the escape of radioactivity to the environment if all of the other lines of defense are breached. The Containment Building also protects the reactor system from outside hazards, such as a tornado or an earthquake.

OPPD has comprehensive plans in place for handling the most improbable plant emergencies. The plans are continually updated to ensure the best protection of the health and safety of the public and power plant workers. Plant employees routinely participate in emergency drills with Nebraska and Iowa emergency response team personnel. These drills are evaluated biennially by Nuclear Regulatory Commission and Federal Emergency Management Agency personnel.

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