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Editorial

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Nuclear reactor

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Editorial

A nuclear reactor, formerly known as an atomic pile, is a device used to initiate and control a fission nuclear chain reaction or nuclear fusion reactions. Nuclear reactors are used nuclear power plants for electricity generation and in nuclear marine propulsion. Heat from nuclear fission is passed to a working fluid (water or gas), which in turn runs through steam turbines. These either drive a ship's propellers or turn electrical generators shafts. Nuclear generated steam in principle can be used for industrial process heat or for district heating. Some reactors are used to produce isotopes for medical and industrial use, or for production of weapons-grade plutonium. As of early 2019, the IAEA reports there are 454 nuclear power reactors and 226 nuclear research reactors in operation around the world.

Just as conventional thermal power stations generate electricity by harnessing the thermal energy released from burning fossil fuels. Nuclear reactors convert the energy released by controlled nuclear fission into thermal energy for further conversion to mechanical or electrical forms.

When a large fissile atomic nucleus such as uranium-235 or plutonium-239 absorbs a neutron, it may undergo nuclear fission. The heavy nucleus splits into two or lighter nucleus, the fission products, releasing kinetic energy, gamma radiation, and free neutrons. A portion of these neutrons may be absorbed by other fissile atoms and trigger further fission events, which release more neutrons, and so on. This is known as a nuclear chain reaction. To control such a nuclear chain reaction, control rods containing nuclear poisons and neutron moderators can change the portion of neutrons that will go on to cause more fission. Nuclear reactors generally have automatic and manual systems to shut the fission reaction down if monitoring or instrumentation detects the physics of radioactive decay also affects neutron populations in a reactor. One such process is delayed neutron emission by number of neutron-rich fission isotopes. These delayed neutrons account for about 0.65% of the total neutrons produced in fission, with the remainder termed prompt neutrons released immediately upon fissionFor use in conditions.

The reactor core generates heat in number of ways:

- The kinetic energy of fission products is converted to thermal energy when these nuclei collide with nearby atoms.
- The reactor absorbs some of the gamma rays produced during fission and converts their energy into heat.
- Heat is produced by the radioactive decay of fission products and materials that have been activated by neutron absorption. This decay heat source will remain for some time even after the reactor is shut down.

A kilogram of uranium-235 (U-235) converted via nuclear processes releases approximately three million times more energy than a kilogram of coal burned conventionally (7.2 × 1013 joules per kilogram of uranium-235 versus 2.4 × 107 joules per kilogram of coal). A nuclear reactor coolant — usually water but sometimes a gas or a liquid metal (like liquid sodium or lead) or molten salt— is circulated past the reactor core to absorb the heat that it generates. The heat is carried away from the reactor and is then used to generate steam. Most reactor systems employ a cooling system that is physically separated from the water that will be boiled to produce pressurized steam for the turbines, like the pressurized water reactor. However, in some reactors the water for the steam turbines is boiled directly by the reactor core, for example the boiling water reactor. The rate of fission reactions within a reactor core can be adjusted by controlling the quantity of neutrons that are able to induce further fission events. Nuclear reactors typically employ several methods of neutron control to adjust the reactor's power output. Some of these methods arise naturally from the physics of radioactive decay and are simply accounted for during the reactor's operation, while others are mechanisms engineered into the reactor design for a distinct purpose. The fastest method for adjusting levels of fission-inducing neutrons in a reactor is via movement of the control rods. Control rods are made of neutron poisons and therefore absorb neutrons. When a control rod is inserted deeper into the reactor, it absorbs more neutrons than the material it displaces—often the moderator. This action results in fewer neutrons available to cause fission and reduces the reactor's power output. Conversely, extracting the control rod will result in an increase in the rate of fission events and an increase in power.

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